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ORIGINAL ARTICLES.

I.—Notes on the Geological Horizon and Palæontology of the 'Soapstone Bed,' in the Lower Coal-measures, near Colne, Lancashire.

By Herbert Bolton, F.R.S.E., Curator of the Natural History Museum, Bristol.

THE 'Soapstone bed,' which has yielded the specimens about to be described by Dr. Henry Woodward, was so named by the late George Wild. It is a thin band of light-grey shale lying from 4 to 7 feet above the 'Mountain Four Feet' mine in the neighbourhood of Colne and Trawden.

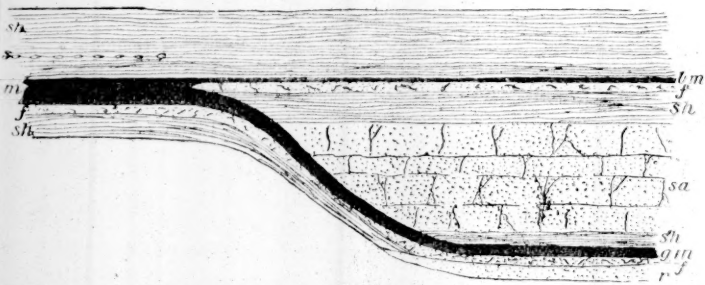
The shale contains an abundance of small flattened nodules, varying in size from half an inch to six inches in length, and from half an inch to two and a half inches in breadth. The vertical thickness rarely exceeds an inch and a half. The shale readily breaks down into a soft unctuous clay on weathering, whilst the outer surface of the nodules undergoes oxidation and breaks away in thin coats. The nodules consist of earthy carbonate of iron, and it is to the oxidation of the latter that breaking up takes place by a process of concentric scaling.

Between the 'Soapstone bed' and the 'Mountain Four Feet' mine are black shales with dark ironstone nodules often full of *Goniatites*, *Pterinopecten*, etc. The horizon from the top of the coal-seam to the 'Soapstone bed' is the most prolific in organic remains in the Lower Coal-measures, in whatever locality it may be met with.

Whilst the horizon of the Soapstone nodule bed is constant over a large area, the beds immediately subjacent to it are not. The Mountain Four Feet mine, upon which it rests under and around the whole of the Burnley coalfield, is seen when traced southwards to be formed by the union of two coal-seams, the 'Gannister mine' and the 'Bullion mine' respectively. These, in the Rossendale area, are separated by a thickness of 40 feet of sandstone and shale, which thins out along a north-west and south-east line between Bacup and Burnley, the thinning out being due to the curving upwards of the lower or Gannister seam to meet the overlying Bullion mine.

Although the Bullion mine can be traced southwards to Oldham, westwards to Padiham, and over the whole of Rossendale, its prolific yield of fossils both in nodules and in the surrounding shales is everywhere remarkable. The 'Soapstone bed' has not been recognised, however, outside the Burnley area, but the occurrence of an Arachnide, *Architarbus subovalis*, from this level at Padiham, would seem to indicate its presence there.

The shales lying upon the Bullion seam outside the Burnley district and those lying upon the Mountain Four Feet in that area are thus one continuous deposit, and have yielded more than thirty-five species of fossils. The chief repository of fossils lies between the roof of the coal-seam and the 'Soapstone bed.' Above the latter there is a marked falling off in genera and species.



Diagrammatic Section showing position of 'Soapstone bed' and relation of the 'Mountain Four Feet' to the 'Bullion' and 'Gannister' mines.

sh. shale; *s.* Soapstone bed shale; *m.* Mountain Four Feet mine; *f.* fireclay; *bm.* Bullion mine; *sa.* sandstone; *gm.* Gannister mine; *r.* Gannister rock.

The nodules of the 'Soapstone bed' are usually of small size, the average being about two inches long by one and a quarter inches wide. The great bulk of them contain a compact mass of the Goniatite, *Dimorphoceras Gilbertsoni*, Phillips, varying in diameter from that of a millet-seed to fifteen millimetres, the latter size being rare. More rarely, the nodules contain bones and scales of fishes, and, rarest of all, examples of Arachnida, Myriopoda, Crustacea, and Amphibia. A census of the Lower Coal-measure fauna was drawn up two years ago by the writer, from which the following lists of fossils occurring in the shales between the coal-seam and the 'Soapstone bed' and in the 'Soapstone bed' itself have been extracted.

Shales over 'Four Feet' and 'Bullion' Mines.

Discina orbicularis, Bolton.
Lingula mytiloides, Sow.
Posidoniella lævis, Brown.
,, *minor*, Brown.
,, *subquadrata*, Hind.
,, *lævigata*, Salter.
Pterinopecten papyraceus, Sow.
Raphistoma (?) *ornata*, Bolton.
Naticopsis globularis, Bolton.
Glyphioceras paucilobum, Phillips.
Dimorphoceras Gilbertsoni, Phillips.
Gastrioceras carbonarium, von Buch.
,, *Listeri*, Martin.
,, *coronatum*, Foord & Crick.
Acanthodes Wardi, Egerton.
Listracanthus spinatus, Bolton.
Rhizodopsis sauroides, Williamson.
Cœlacanthus elegans, Newberry.
Elonichthys semistriatus, Traquair.

FOSSILS FROM 'SOAPSTONE BED.'

Dimorphoceras Gilbertsoni, Phillips.
Pygocephalus Cooperi, Huxley.
Prestwichia rotundata, H. Woodw.
Arthritarbus subovalis, H. Woodw.
Hybodopsis Wardi, Barkas.
Acanthodes Wardi, Egerton.
Elonichthys Aitkeni, Traquair.
Hylonomus Wildi, A. S. Woodward.
Microsaurian remains unidentified.

It will be seen that the fauna of the 'Soapstone bed' differs markedly from that of the underlying shales, although a few forms are common to the two.

Further examination of the bed cannot now be made in the neighbourhood of Carre Heys, as the mines have been long abandoned, and nothing remains but the grass-grown spoil-heaps of débris now reduced to a condition of soft clay in which the small nodules can occasionally be found.

The following list includes most, if not all, of the allied genera and species already recorded from the Lancashire Coal-measures :—

Anthrapalæmon Etheridgei, Peach, Trans. R. S. Edinb., 1880, vol. xxx, pp. 76–78, pl. viii, figs. 3*a*–*g*.

A cephalothorax of this species was found high up in the Lower Coal-measures of Cant Clough, near Burnley, in 1884.

Pygocephalus Cooperi, Huxley, Quart. Journ. Geol. Soc., 1857, vol. xiii, p. 363, pl. xiii; 1862, vol. xiv, p. xci; vol. xviii, p. 420; see also H. Woodward, Trans. Geol. Soc. Glasgow, 1866, vol. ii, p. 234.

Found by the late George Wild in the 'Soapstone bed,' above the Mountain Four Feet coal, at Carre Heys, near Colne. A second specimen has been found in the Middle Coal-measures of Medlock Park Bridge, near Ashton-under-Lyne. Both examples are in the Manchester Museum of Owens College. A third specimen has been found by Messrs. Baldwin and Sutcliffe in an ironstone nodule-band occurring 60 yards above the Royley or Arley mine at Sparth Bottoms, Rochdale.[1]

Arthropleura (*olim Eurypterus*) *mammata*,[2] Salter, 1863, Quart. Journ. Geol. Soc., vol. xix, p. 84.

Fragments of this species belonging to the head, lateral portions

[1] See Catalogue Type Fossils in Museum Handbook of the Owens College Museum, Manchester, by H. Bolton, 1893, where on p. 23 is a description and figure of the type-specimen of *Pygocephalus Cooperi*, Huxley. Eight specimens of this species have been obtained by the British Museum (Natural History) from Coseley Coalfield, near Dudley, in Mr. Henry Johnson's collection, etc.

[2] Remains of this genus have been discovered by Mr. James McMurtrie, F.G.S., in the Coal-measures of Radstock, Somerset, and by Mr. J. W. Kirkby in the Coal-measures of Fifeshire. They agree (according to Dr. Woodward) most closely with the *Arthropleura armata* of Jordan from the Coal-measures of Saarbruck, Rhenish Prussia (see Palæontographica, 1856, Bd. iv, Taf. 2, figs. 4 and 5), and from their peculiar pustulate, mammate, and spinous ornamentation may prove, when more remains have been obtained, to be parts of the body-segments of a large Arachnid. See Pal. Soc. Mon. Merostomata, by H. Woodward, pt. iv, 1872, pp. 163–168; *cf.* also figure and description of *Eurypterus scabrosus*, H. W., GEOL. MAG., 1887, pp. 481–484, Pl. XIII, from Lower Carboniferous shales, Eskdale, Scotland.

of the body-segments, and parts near the tail were found at the pit top of Pendleton colliery by Messrs. Gibbs and Rhind. The horizon was afterwards found to be the 'ferny metal' under the Big Coal or Rams Mine.

Cyclus Johnsoni, H. Woodward, Geol. Mag., 1894, p. 537, Pl. XV, Figs. 4–7.

A single specimen is recorded from the roof of the Fairbottom Mine in the Middle Coal-measures at Bardsley, near Oldham.

Cyclus Scotti, H. Woodward, Geol. Mag., 1893, p. 28 (woodcut); ibid., 1894, p. 537, Text-figure, and Pl. XV, Fig. 3.

The type-specimen of this species was found by the late George Scott in shale over the Gannister coal at the Old Meadows colliery, Bacup, Lancashire (now preserved in the Owens College Museum, Manchester).

Prestwichia rotundata, H. Woodw., Quart. Journ. Geol. Soc., 1867, vol. xxiii, pl. i, fig. 1.

An example of this species is in the Kay-Shuttleworth Collection of the Manchester Museum. It was obtained from Padiham, near Burnley, and although its precise horizon is not recorded the writer regards it as undoubtedly just above the Mountain Four Feet mine.

Prestwichia Birtwelli, H. Woodw., Geol. Mag., 1872, Vol. IX, Pl. X, Figs. 9 and 10; Pal. Soc. Mon. Merostomata, part v, 1878, p. 247, pl. xxxi, figs. 7*a–c*.

From the Cornfield Pit, River Calder, Padiham, near Burnley.

Bellinurus bellulus,[1] König, 1820 (*olim Limulus trilobitoides*, Buckland, 1836), H. Woodw., Pal. Soc. Mon. Merostomata, part v, 1878, p. 239, pl. xxxi, figs. 3*a*, *b*.

A specimen of this species was obtained many years ago from Coal-measures at Oldham, and deposited in the old Natural History Museum in Manchester. No horizon was stated, and the specimen cannot now be traced.

A second specimen has been found by Messrs. Baldwin and Sutcliffe at Sparth Bottoms, Rochdale, where it occurred 135 feet above the Royley or Arley mine of the Middle Coal-measures.

Arachnida.

Architarbus subovalis, H. Woodw., Geol. Mag., 1872, Vol. IX, p. 385, Pl. IX, Figs. 1*a*, *b*.

The type of this species was described by Dr. Henry Woodward in 1872, the specimen occurring in a clay-ironstone nodule lying about four feet above the 'four feet mine' or 'bone-coal' of Padiham. The horizon here given is that of the Soapstone bed, the 'four feet mine' being the Mountain Four Feet.

[1] Dr. F. A. Bather suggests that this specimen ought to be called *Bellinurus lunatus*, Martin, sp., having been described by that author as *Entomolithus* (*Monoculus*) *lunatus* in his (Martin's) "Petrificata Derbiensia" in 1809, pl. xlv, fig. 4.

SCORPIONIDÆ.

Eoscorpius Sparthensis, Baldwin & Sutcliffe, Quart. Journ. Geol. Soc., 1904, vol. lx, pp. 394–399, figs. 2 and 3 in text.

The type of this species was found by Messrs. Baldwin and Sutcliffe at Sparth Bottoms, Rochdale, at 135 feet above the Royley or Arley mine of the Middle Coal-measures. (It is now in the Rochdale Museum.)

MYRIOPODA.

Euphoberia Browni, H. Woodw.,[1] GEOL. MAG., 1871, Vol. VIII, pp. 102–104, Pl. III, Fig. 6.

Found in shale in which the fossil tree trunks occur at Dixon Fold on the Lancashire and Yorkshire Railway. The horizon is, I believe, that of the shales lying over the Doe mine in the Middle Coal-measures.

Euphoberia ferox, Salter,[2] sp., 1863.

Remains of this species were found in association with *Arthropleura mammata* at the pit top of Pendleton colliery, the horizon being the 'ferny metal' under the 'Big Coal' or Rams mine of the Middle Coal-measures. It has also been found by Messrs. Sutcliffe and Baldwin at Sparth Bottoms, 45 yards above the Royley mine.

Xylobius sigillariæ, J. W. Dawson,[3] 1860, Quart. Journ. Geol. Soc., vol. xvi, pp. 268–277.

A specimen (species undeterminable) is in the Manchester Museum, having been obtained from the waste-heaps of the Ashton Moss colliery by Mr. Robert Cairns.

Insecta are represented by an imperfect specimen of a Neuropterous insect from 47 yards above the Royley or Arley mine at Sparth Bottoms, Rochdale, and a doubtful larval form of *Etoblattina* from about 60 yards over the Royley or Arley mine at the same place. Both specimens were found by Messrs. Baldwin and Sutcliffe.

II.—NOTES ON SOME CRUSTACEANS AND TWO MYRIOPODS FROM THE LOWER COAL-MEASURES NEAR COLNE, LANCASHIRE.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

BY the courtesy of my friend Mr. Herbert Bolton, the Curator and Secretary of the Bristol Museum, several specimens have been placed in my hands for examination. They were collected by Mr. Peter Whalley from the 'Soapstone bed,' a little distance above

[1] The type-specimen was obtained by the late Mr. Thomas Brown, of Glasgow, in a clay-ironstone nodule from the Coal-measures of Kilmaurs.

[2] Described as a *Eurypterus* by Salter, Quart. Journ. Geol. Soc., 1863, vol. xix, p. 86, really a spined Myriopod; see H. Woodward, "Myriopods of the Coal Period," GEOL. MAG., 1887, pp. 1–10 and 116–117 (figs. in text).

[3] A Chilognathous Myriopod from the hollow trunk of an erect *Sigillaria* in the South Joggins Coalfield, Nova Scotia. This genus was first found in Scotland by Mr. Thomas Brown in the Coal-measures of Kilmaurs, and described by Dr. H. Woodward in Trans. Geol. Soc. Glasgow, 1866, vol. ii, p. 234, pl. iii, fig. 11. A second specimen from the clay-ironstone band, Cooper's Bridge, was obtained by Mr. Joseph Tindall, of Huddersfield, and figured on the same plate (op. cit.), figs. 13 and 13*a*. Noticed by Mr. Edward Binney, F.R.S., Trans. Lit. and Phil. Soc. Manchester, Jan. 8th, 1867; see GEOL. MAG., 1867, Vol. IV, p. 132.

the 'Bullion Mine' (or 'Mountain Four Feet'), on the hill near Colne, Lancashire, and he permits me to figure and describe them.

All the specimens are enclosed in small, elliptical nodules of clay-ironstone, evidently formed around the organisms by a process of concretionary action at the time of their embedment in the sediment forming the layer in which the nodules occur, the fossils being, as usual in such cases, exposed by splitting the concretions open along their periphery.

CRUSTACEA.

DECAPODA—Macroura.

1. Anthrapalæmon serratus, H. Woodw., sp. nov.
(Text-fig. 1.)

This specimen is represented by only a portion of one side of a nodule; the remainder and counterpart are alike wanting.

The Crustacean is disposed longitudinally on the split surface of the matrix, and is 90 millimetres in length, of which the cephalothorax measures 50 mm. long, and the five abdominal segments 40 mm.; the rostrum, which is smooth, sharply pointed, ridged, and slightly curved downwards in front, is 20 mm. in length, the anterior border on the left side is 11 mm. broad; the antennules and antennæ are only imperfectly preserved; the outer antenna was furnished with a broad, recurved spatulate scale 14 mm. in length. The outer latero-anterior margin bears four short serrations, but the rostrum appears to have been quite smooth. Only four of the five pairs of ambulatory legs are imperfectly preserved, but the presumably larger anterior chelate pair, if present, are not visible in the fossil.

The latero-posterior border of the carapace is slightly rounded off, and the margins raised and thickened. The median line of the five abdominal segments is slightly raised, and the lateral margins truncated. If epimeral pieces existed to these segments they are hidden in matrix or are not now preserved. The caudal segment and appendages are wanting. The surface of the body-segments is finely punctate; the surface of the cephalothoracic shield has doubtless adhered to the other, lost side of the split nodule. A very small maxilliped with a three-jointed palpus attached appears lying on the surface of the cephalothorax where the carapace has been removed (unfortunately this is not shown in Fig. 1).

This specimen approaches most nearly to Dr. B. N. Peach's *Anthrapalæmon Etheridgei*[1] from the Carboniferous rocks of Eskdale, but in the latter the rostrum bears a row of four or five well-marked small spines, and the extremity is also serrated on each side, the antennal scales are more oval in form, not so obliquely curved and spatulate as in our specimen, nor is the border of the cephalothorax serrated along the latero-anterior margin as in this example from Colne. I am therefore inclined to separate this form specifically, giving it the trivial name of *serratus*.

[1] Trans. R. S. Edinb., 1880, vol. xxx, pp. 76–78, pl. viii, figs. 3*a*–*g*.

Locality and formation: 'Soapstone bed,' a little distance above the Bullion Mine, Colne Hill, Lancashire. Lower Coal-measures. Collection of Mr. Peter Whalley.

2. Anthrapalæmon Woodwardi, R. Etheridge, jun., 1879. (Text-fig. 2.)

Quart. Journ. Geol. Soc., 1879, vol. xxxv, p. 468, pl. xxiii, figs. 4–9.

Among a number of Lower Carboniferous Crustaceans from the cement-stone of the Calciferous Series near New Castleton, Roxburghshire, Mr. Robert Etheridge figured and described, in 1879, several

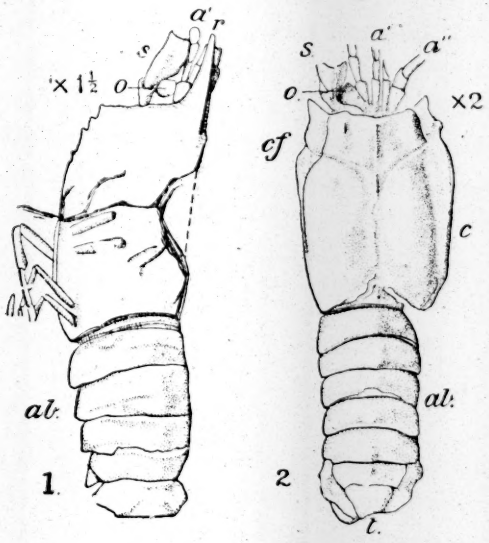


Fig. 1.—*Anthrapalæmon serratus*, H. Woodw., sp. nov. Enlarged 1½ nat. size. Soapstone bed, Lower Coal-measures: Carre Heys, Colne, Lancashire. *a'*, antennule; *s*, scale at base of antenna; *r*, rostrum; *o*, eye; *ab*, abdomen.

Fig. 2.—*Anthrapalæmon Woodwardi*, R. Etheridge, jun., 1879. Formation and loc. same as Fig. 1. *a'*, antennule; *a''*, antenna; *o*, stalked eye; *cf*, cervical furrow; *c*, cephalothorax; *ab*, abdomen; *t*, telson or caudal segment.

examples which he referred to this species (originally figured from a less perfect example, Quart. Journ. Geol. Soc., 1877, vol. xxxiii, p. 872, pl. xxvii).

The following is Mr. Etheridge's description:—

"Sp. char. Carapace oblong, narrowing towards the anterior part, and divided into two unequal portions by the cervical groove, the posterior being the largest; relative convexity unknown. Anterior lateral margins[1] not spinous and without serrations; posterior lateral angles rounded; posterior margin concave. Cervical groove strongly marked and widely V-shaped. Middle line of the carapace

[1] Produced at antero-lateral angles into a spine (see Fig. 2 above).

occupied by a strong ridge continuous with the rostrum and extending to the posterior margin, and flanked on each side by a straight or slightly curved lateral ridge extending from the frontal border to the posterior margin. Like the central one, these ridges are minutely crenulated. That portion of the carapace anterior to the cervical groove is crushed, and cannot satisfactorily be made out." [Mr. Etheridge thought this form probably possessed a prominent rostrum, but the figures given on his pl. xxiii, op. cit., do not represent anything more than a very slight double spine.[1]]

"Flagella of the antennæ bent obtusely outwards, composed of numerous minute subdivisions. Antennæ having a peduncle or protopodite of four segments, and terminating in two slender filamentous whips. First pair of chelate appendages probably present, small, elongate. Eyes large and reticulated. Abdominal segments six in number, with pointed pleuræ[2] and a well-marked central line extending throughout their whole length, and corresponding with the central ridge of the carapace; articular area small, but distinctly visible, defined by a small transverse ridge on each segment. Telson primarily consisting of a central hastiform plate, flanked on each side by two lateral caudal swimming-lobes, which arise from and are articulated to the sixth segment of the abdomen."

I do not think I need add a further description to that by Mr. Etheridge. The impressions left by the rather large eyes, the basal joints of the antennules, and the outer antennæ, with portions of their flagellæ, can be made out. The small limbs are not preserved in this specimen, nor the chelate anterior pair.

Length of Mr. Whalley's specimen 65 mm., length of cephalothorax 33 mm., breadth 22 mm., length of five abdominal somites 20 mm., length of second abdominal segment 7 mm., length of caudal plates 10 mm. (probably longer).

Locality and horizon: Colne Hill, Soapstone bed, Lower Coal-measures. Original specimen in Mr. Peter Whalley's collection.

3. Anthrapalæmon Traquairii (?), Peach.

Trans. Roy. Soc. Edinburgh, 1880, vol. xxx, pt. 1, p. 80, pl. x, figs. *5a–f*.

In Mr. Whalley's collection is a rather large Arthropod, probably referable to Dr. Peach's species *A. Traquairii*, from the Lower Carboniferous rocks of Eskdale. The specimen is very obscure, and I have therefore not figured it; but a brief note may serve to record it, and to stimulate further research, which it may be hoped will result in the obtaining of more perfect material for study.

The whole animal measures $8\frac{1}{2}$ cm. in length, by 2 cm. in breadth. The carapace is $3\frac{1}{2}$ cm. long, and appears to have slipped forward in the matrix (when soft) exposing 2 cm. length of the uncovered thoracic region with the imperfectly preserved thoracic limbs; behind these, again, are the traces of the five abdominal somites; the nodule

[1] The presence of a rostrum is not confirmed by Mr. Whalley's specimen, and I am doubtful whether this species had a prominent rostrum.

[2] The pleuræ cannot be seen in Mr. Whalley's specimen.

has been truncated just where the caudal appendages would join the abdominal segments. The carapace is rounded posteriorly, and the cervical furrow is well-marked. There is also a median dorsal furrow down the centre of the carapace. The limbs are very imperfect. Two obscurely defined scale-like bodies are present in front of the head.

We can only hope for better material from the Soapstone nodules, to enable one to determine this interesting fossil.

Locality and formation, the same as the preceding specimens.

TRACHEATA (Air-breathers of the Coal Period).

ARCHIPOLYPODA, Scudder.

Fam. 2.—EUPHOBERIDÆ, Scudder.

Genus EUPHOBERIA, Meek & Worthen.

Palæontology of Illinois, 1868, p. 556.

1. EUPHOBERIA BROWNII, H. Woodw., 1871.

GEOL. MAG., Vol. VIII, Pl. III, Figs. 6*a–c* (in clay-ironstone, Coal-measures, Kilmaurs, near Glasgow).

The specimen from Mr. Peter Whalley's collection of which a figure is given here (Fig. 3) is identical with *Euphoberia Brownii*, from Kilmaurs, figured and described by me in 1871.

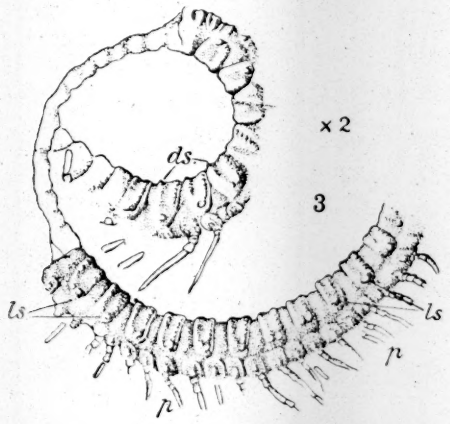


FIG. 3.—*Euphoberia Brownii*, H. Woodw., 1871. Enlarged twice natural size. From Soapstone bed, Coal-measures: Carre Heys, Colne, Lancashire. *ds*, dorsal surface; *ls*, bases of spines; *p*, *p*, walking-feet.

Both sides of the nodule from Colne Hill are preserved and expose a coiled up Myriopod, having indications of a head and about 30 equal-sized segments, each composed of a saddle-shaped plate rounded at its lower edge, covering the dorsal region and having a raised rounded border before and behind; the interlocking posterior smooth border is of equal breadth behind the

saddle, the smooth margin of which passes under the succeeding segment; at the lower lateral rounded border of each saddle-shaped plate the base of a round spine (?) is seen broken off; occasionally the base is double. Some of the saddle-plates have a third additional ridge upon them. Below each saddle-shaped dorsal plate are two smaller ventral plates,[1] also ridged, to each of which a pair of slender, six- or seven-jointed walking-limbs is articulated. The saddle-plates of the segments nearest the head have a delicate crenulation along their raised margins. The head has two rounded lobes, which are probably the eyes, although the facets are not very distinct. The last segment (telson ?) is smaller than the rest and appears to be somewhat semicircular in form; quite 15 to 20 pairs of jointed ambulatory appendages can be made out, two pairs being attached to each double-segment.

Measured around the curve of the coiled-up specimen the body is 8 centimetres in length; the segments 10 mm. deep and about 8 mm. long; the walking-legs are about 10 mm. in length. There is a second specimen in Mr. Whalley's collection, with counterpart (broken off at each end), which measures 3 cm. in length.

Euphoberia Brownii is closely related to *E. armigera*, described by Messrs. Meek & Worthen in their great work on "The Geology and Palæontology of Illinois, U.S.," 1868, vol. iii, p. 556, figs. *a–d*, from the clay-ironstone nodules of the Coal-measures, Grundy County, Illinois, reproduced in our Pl. III. Geol. Mag., 1871, p. 104.

Locality and formation: from the Soapstone bed, Colne Hill. Lower Coal-measures. In the collection of Mr. Peter Whalley.

2. Xylobius moniliformis, H. Woodw., sp. nov.
(Text-fig. 4.)

The earliest recorded examples of Chilognathous Myriopods met with in a fossil state were discovered by Sir William Dawson in the hollow trunk of a still erect *Sigillaria*, in a bed of coal on the South Joggins Coalfield, Nova Scotia, and described by him in the Quarterly Journal of the Geological Society of London in 1853, vol. ix, p. 58. A fuller description by the same author followed December 15th, 1859 (op. cit., vol. xvi, p. 268). These terrestrial Myriopods have also been found in the Coal-measures of Illinois by Messrs. Meek & Worthen, and in the Coal-measures of Kilmaurs, near Glasgow, by Mr. Thomas Brown. Some of these forms were described and figured by me in the Trans. Glasgow Geol. Soc., 1866, vol. ii, p. 235, pl. iii, figs. 11–13.

In 1867 Mr. Binney exhibited fossils collected by Mr. Joseph Tindall, of Huddersfield, from the Lower Coal-measures near that town. One of these was a remarkably good example of *Xylobius* in a nodule of clay-ironstone, having about 46 well-preserved articulations to its body. This specimen showed the segments to have been ornamented with transverse, finely undulating lines, as

[1] Not clearly shown in the figure.

noticed in the original examples from Nova Scotia, and I referred it in my description to Dr. Dawson's species *Xylobius sigillariæ*.[1]

The specimen here figured (Fig. 4) from near Colne, Lancashire, shows only a part of the body of a Myriopod, consisting of about 25 rounded segments, truncated at the larger anterior end by the loss probably of the half of the nodule in which the animal is imbedded, the part preserved being the posterior or caudal moiety with its counterpart. Each somite or segment has a raised ring or ridge passing around near the anterior border, having (so far as exposed upon the matrix) a single row of upwards of 10 minute oblong bead-like ornaments on it, with a plain, slightly raised moiety forming the posterior articular boundary of each segment. Beyond the first 13 or more anterior segments, counting from the truncated end, the body-rings gradually diminish in size towards the posterior extremity, which is slightly curled round like the tail of the letter J. Length of the entire body about 6 cm. Length of six segments 20 mm.,

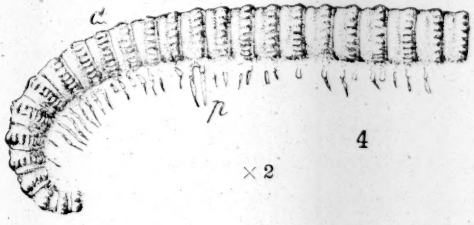


FIG. 4. — *Xylobius monitiformis*, H. Woodw., sp. nov. Soapstone bed, Lower Coal-measures: Carre Heys, Colne, Lancashire. Enlarged twice natural size. *d*, dorsal aspect of specimen; *p*, walking-feet.

width of anterior segment 8 mm. Minute walking-legs, about 5 mm. long, are to be seen for almost the entire length of the body; there are two pairs (where preserved) to each segment.

The interest attaching to this specimen of *Xylobius* consists in the preservation of the extremely beautiful ornamentation on the body-segments, reminding one of the jointed columns of some Silurian Crinoid such as *Gissocrinus* or *Gothocrinus*. It is to be regretted that the remainder of the nodule has not been preserved, as we might then have been able to describe the head, and have ascertained the entire length of the body.

Locality and formation: Soapstone bed, Lower Coal-measures, Colne Hill, Lancashire. In the collection of Mr. Peter Whalley.

Amongst the nodules sent up by Mr. Whalley there is in one the remains of a fish, *Acanthodes Wardii*; another contains two very small Gasteropods which have not been identified.

Mr. G. C. Crick, F.G.S., has kindly examined two other nodules for me, and writes as follows:—

[1] See Trans. Lit. and Phil. Soc. Manchester, January 8th, 1867; GEOL. MAG., 1867, Vol. IV, p. 132; and Trans. Glasgow Geol. Soc., 1866, vol. ii, p. 236, pl. iii, figs. 13 and 13*a*.

Dimorphoceras discrepans (T. Brown[1]).

In one nodule is exhibited about one-half of the lateral area and a portion of the periphery of the septate part of a Goniatite, 3 mm. in diameter, that seems to be referable to this species. The test is not preserved, but the septa are well shown.

Orthoceras, sp. 1.

In the same nodule as the example of *Dimorphoceras discrepans* there is a fragment of a slender, slowly-tapering *Orthoceras*, 8 mm. long and about 2 mm. in diameter. Rather more than the uppermost 2 mm. form part of the body-chamber; the rest is entirely septate and exhibits fifteen chambers, so that these may be described as very shallow, about five occupying the space of 2 mm. The septa are slightly oblique; the cross-section is elliptical; the siphuncle appears to be nearly marginal and situated at the extremity of the long axis. The test is thin and polished. *Orthoceras asciculare*, T. Brown,[2] is described as having the siphuncle near the side, but, judging from the figure, that species has deeper chambers than the present specimen.

Orthoceras, sp. 2.

Another nodule contains a fragment of a slender *Orthoceras*, about 6 mm. long. The specimen is only partially exposed, the greatest width being only 1·5 mm., but it seems to belong to a more rapidly tapering shell than sp. 1. Although nearly covered with the test, it appears to be entirely septate, the chambers being a little deeper than in sp. 1, eight chambers occupying about 5 mm. The test is thin, polished, and has very feeble annulations, which apparently correspond to the septa, whilst the surface between the annulations is covered with exceedingly fine transverse lines.

III.—Sedgwick Museum Notes.
New Fossils from the Haverfordwest District. IV.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XXIII.)

THE following species of Brachiopoda were recorded by Messrs. Marr & Roberts[3] from the Ordovician beds of the Haverfordwest district:—

Llandeilo Limestone.
Leptæna [*Plectambonites*] *sericea*, Sow.
Orthis striatula, Conr.

Dicranograptus Shales.
Orthis argentea, His.
Siphonotreta micula, McCoy.
and "other horny brachiopods."

[1] T. Brown, Fossil Conchology, 1849, p. 28, pl. xxi, figs. 8, 8*a*, and 15 (*Goniatites discrepans*). See also Foord & Crick, Cat. Foss. Ceph. British Museum, pt. 3, 1897, p. 222 (*Dimorphoceras discrepans*).

[2] T. Brown, Trans. Manchester Geol. Soc., vol. i, 1841, p. 220, pl. vii, fig. 39; and T. Brown, Foss. Conch., 1849, p. 249, pl. xxix*, fig. 29.

[3] Marr & Roberts: Q.J.G.S., vol. xli (1885), pp. 476–491.

Robeston Wathen Limestone.

Orthis elegantula, His.
,, *Actoniæ*, Sow.
,, *calligramma*, Dalm.
Leptæna [*Plectambonites*] *transversalis*, Wahl.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.

Trinucleus seticornis Beds.

(*a*) Sholeshook Limestone.

Orthis elegantula, Dalm.
,, *testudinaria*, Dalm.
,, *calligramma*, Dalm.
Leptæna [*Plectambonites*] *quinquecostata*, McCoy.
,, [,,] *sericea*, Sow.
,, [*Christiania*] *tenuicincta*, McCoy.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.

(*b*) Redhill Beds.

Lingula sp.
Leptæna [*Plectambonites*] *sericea*, Sow.
,, [*Christiania*] *tenuicincta*, McCoy.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.
Orthis elegantula, Dalm.
,, *calligramma*, Dalm.

(*c*) Slade Beds.

Lingula sp.
Strophomena [*Leptæna*] *rhomboidalis*, Wilck.
,, *corrugatella*, Dav.
Leptæna [*Plectambonites*] *sericea*, Sow.
Orthis biforata, Schloth.
,, *elegantula*, Dalm.
,, *testudinaria*, Dalm.
,, *calligramma*, Dalm.
,, *porcata*, McCoy (?).

We are able to make the following additions to the foregoing list by means of the large series of Brachiopods collected by Mr. V. M. Turnbull, though the specific determination of many specimens (probably including some new species) must await the acquisition of better material.

I. Llandeilo Limestone.

Trematis multistriata, sp. nov. Lampeter Velfrey.
Strophomena sp. Lampeter Velfrey.

II. Dicranograptus Beds.

(*Orthis argentea* zone.)
Acrotreta Nicholsoni, Dav.
Orbiculoidea perrugata, McCoy.

III. Robeston Wathen Limestone.

Plectambonites sericea, Sow.

IV. Trinucleus seticornis Beds.

(*a*) Sholeshook Limestone.

Crania Turnbulli, sp. nov.
Orthis Actoniæ, Sow.
Triplecia insularis, Schloth.
Plectambonites scissa, Salt.

(*b*) Redhill Beds.

Orthis aff. *Bouchardi*, Dav.
Plectambonites scissa, Salt.
,, *papillosa*, sp. nov.
Strophomena antiquata, Sow., var.

(*c*) Slade Beds.

Lingula brevis, Portl. (?).
Lingula, two sp. indet.
Crania Grayi, Dav., var.
Orbiculoidea perrugata, McCoy.
,, (*Pholidops?*) *oblongata*, Portl.
Orthis vespertilio, Sow.
,, *Sowerbyana*, Dav.
,, *crispa*, McCoy.
,, *Actoniæ*, Sow.
,, *porcata*, McCoy, var. nov. *sladensis*.
,, *testudinaria*, Dalm., var.
,, (several indet. sp.).
Triplecia insularis, Schloth.
Strophomena antiquata, Sow., var. *scabrosa*, Dav.
,, *expansa*, Sow.
,, *mediocostalis*, sp. nov.
,, sp.
Plectambonites papillosa, sp. nov.
Atrypa imbricata, Sow.
Meristella cf. *crassa*, Sow.
Hyattella pentagonalis, Reed (?).
Zygospira Hicksi, sp. nov.

Trematis multistriata, sp. nov. (Pl. XXIII, Figs. 1, 1*a*.)

Description.—Shell nearly orbicular, a little wider than long. Brachial valve gently convex, most so towards beak, which is marginal and slightly projects over posterior margin. Surface of valve covered with fine, raised, thread-like lines radiating from the beak, and increasing in number towards margin by interpolation of secondary and tertiary shorter lines at half, or a quarter, or less than a quarter the length of the primary lines. All lines of equal strength and at equal distances, the interspaces being about twice the width of the lines. The median lines are straight, but towards the cardinal region the lines curve gently backwards. Interspaces between radiating lines occupied by small transversely rectangular or subquadrate pits, a single row lying along each interspace, and separated by small low transverse bars. The radial threads number on margin about 200. A few low concentric growth ridges are present on the surface.

Dimensions.

Length	16·5 mm.
Width	18·5 mm.

Locality.—Quarry near Church, Lampeter Velfrey.

Horizon.—Lower Llandeilo Limestone.

Remarks.—This beautifully ornamented shell is closely allied to *Trematis siluriana*, Dav.,[1] but the radial lines are rather more numerous and closer together, the interpolation of secondary and tertiary lines less regular, the pits less conspicuous, and the beak more marginal. The shell is well preserved in our specimen, but unluckily we know nothing of the internal characters nor of the opposite valve. *T. ottawaensis*, Billings,[2] from the Trenton Limestone, appears to be a nearly allied form, but, apart from the

[1] Davidson: Mon. Brit. Foss. Brach., vol. iii, p. 71, pl. vi, figs. 8, 8*a*, 8*b*.
[2] Billings: Pal. Foss. Canada, vol. i (1862), p. 53, fig. 58.

presence of the pits, the shape of the shell, position of beak, and radial ornamentation resemble *Schizocrania filosa*, Hall.[1] However, the generic position of our specimen does not admit of a doubt. It appears to be specifically distinct from any so far described, none of the other British species, except *T. siluriana*, being closely allied, and the name *multistriata* is therefore proposed for it.

Crania Turnbulli, sp. nov. (Pl. XXIII, Figs. 2, 2*a*.)

Description.—Shell subquadrate, wider anteriorly, upper valve strongly elevated, convex, subpyramidal; apex situated nearer anterior than posterior margin; posterior slope somewhat flattened; anterior slope short, steep. Cast of interior of upper valve showing pair of anterior adductor muscle-scars situated a little behind apex, nearly in middle of shell, less than their own diameter apart, deep, subcircular, each partly divided internally into two subequal portions by a triangular projection from outer anterior side. Pair of shallow oval posterior adductor impressions, submarginal, posterior, situated about twice their diameter apart at end of broad, slightly diverging shallow grooves running back from anterior adductors. Surface of valve ornamented with very numerous fine, closely-set, subparallel, thread-like, raised lines of equal strength, radiating from umbo and running at right angles to the four sides, with many shorter similar lines of equal strength but of various lengths intercalated. To the four angles of the shell only a few of the radial lines run the whole way from the umbo, the majority curving round on each side to meet the adjacent sides at right angles. A few weak concentric growth-lines present.

Dimensions.

Width at anterior end, 17 mm.	Length, 12·5 mm.
Width at posterior end, 13 mm.	Height, 5·0 mm.

Locality.—Sholeshook Railway Cutting.

Horizon.—Sholeshook Limestone.

Remarks.—Only the impression of the exterior of the shell and the cast of the interior of the same valve, both in a somewhat imperfect state, but belonging to the same individual, are known to me. They present characters which differentiate them from other described species. The nearest allied appears to be *Cr. Crofti*, Dav.,[2] but this shell has an anterior depression on the surface, the posterior adductors are placed nearer together, there is an internal ridge on the posterior face of the shell, and the external ornamentation is rather coarser. *Cr. divaricata*, McCoy,[3] is quite distinct.

Crania Grayi, Dav., var. (Pl. XXIII, Fig. 3.)

There is one small specimen of a *Crania* which is almost indistinguishable from *C. Grayi*, Dav.[4] It consists of an upper

[1] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 1, 1892, p. 143, pl. iv G, figs. 22–30.

[2] Davidson: Mon. Brit. Foss. Brach., vol. v, Suppl. Silur., p. 215, pl. xvii, figs. 54–56.

[3] Ibid., vol. iii, p. 78, pl. viii, figs. 7–12.

[4] Davidson: Mon. Brit. Foss. Brach., vol. iii, p. 82, pl. viii, figs. 22–24.

valve of a subcircular, conical shape, with a non-central elevated umbo situated at about one-third the diameter from the posterior edge. The surface is ornamented with about fifty strong radiating ribs, equidistant, of equal strength, and projecting a little beyond the margin of the shell, with 2–3 much finer shorter ones between.

Dimensions.

Diameter	4·0 mm.
Height	1·5 mm.

Locality.—Roadside near St. Martin's Cemetery, Haverfordwest.

Horizon.—Slade Beds.

Remarks.—*C. Grayi* is, according to Davidson, only found in the Wenlock Limestone. The American Ordovician species *C. Lælia*, Hall,[1] from the Utica and Lorraine groups appears to be allied to the Slade species.

Orthis (Plesiomys) porcata, McCoy, var. nov. *sladensis*.
(Pl. XXIII, Figs. 4–7.)

This species was recorded with a query by Messrs. Marr & Roberts from the Slade Beds. Many fine specimens of a variety of it are included in Mr. Turnbull's collection. The variety is distinct, particularly with regard to its internal characters, and may have to be regarded as specifically different to the typical *O. porcata*.

Description.—Shell biconvex, semi-elliptical, wider than long, broadest at about half its length; hinge-line straight, less than greatest width of shell; cardinal extremities obtusely angular, sides and front rounded. Pedicle valve moderately convex, less so than brachial valve; no medial depression; beak moderate, slightly incurved, not prominent, but rising a little above hinge-line; hinge-area triangular, not very wide, inclined. Brachial valve slightly more convex than opposite valve; beak rather smaller, slightly incurved; area triangular, nearly vertical, of approximately the same size. Interior of pedicle valve with small, elongated-suboval, muscular area, definitely circumscribed, acutely indented in front, about one-fifth the length of the valve; teeth large. Brachial valve with oval cardinal process; low rounded median ridge running forwards for about one-fourth the length of the valve between deep, narrow, elongated muscular scars; crura stout. Surface of valves covered with numerous subequal fine rounded ribs, slightly curved on lateral portions of shell, increasing by bifurcation at about one-fourth their length, and frequently again nearer margin, to about 150–160 round margin. A few strong concentric growth ridges generally present, and a fine concentric striation.

Dimensions.

	I.		II.
Length	22·5 mm.	...	25·0 mm.
Width at hinge-line	22·0 mm.	...	27·0 mm.
Maximum width	28·5 mm.	...	36·0 mm.

Locality.—Roadside near St. Martin's Cemetery, Haverfordwest.

Horizon.—Slade Beds.

[1] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 1, 1892, pl. iv H, fig. 1.

Remarks.—In typical examples of *O. porcata*,[1] as well as in the type-specimen, the pedicle valve is flattened, and only convex about the beak and on the lateral portions; there is also a moderate depression down the middle of the valve, and the muscular area is remarkably square. In none of these points does our variety agree with it. The ornamentation of the surface varies much in the species, but ours is not in complete agreement with any figured, though not much stress need be laid on this fact. This new variety may be named *sladensis*.

Orthis aff. Bouchardi, Dav. (Pl. XXIII, Figs. 8, 9.)

Description.—Shell subquadrate, rounded, a little wider than long, plano-convex; hinge-line straight, a little less than the greatest width. Pedicle valve convex, slightly keeled, rounded; beak high, incurved; hinge-area triangular, large, vertical or steeply inclined. Brachial valve flattened, with deep, broad median sinus of nearly uniform width, deeply sinuating anterior margin; small inconspicuous beak; narrow hinge-area. Interior of pedicle valve with small teeth, and faint muscular impressions. Interior of brachial valve with bilobed cardinal process; stout strong crura; two pairs of adductor impressions, distinct, rather wide apart, with low rounded ridge between them, anterior pair elongated oval, twice as long as posterior pair, which are subcircular. Surface of valves ornamented with about 30 to 40 subangular ribs, mostly simple, but some bifurcating, and with a shorter one intercalated between each pair; usually finely imbricated concentrically.

Dimensions.

Length	6·0 mm.
Width at hinge	7·0 mm.

Localities and Horizons.—Redhill Beds, Prendergast Place; Slade Beds, near St. Martin's Cemetery, Haverfordwest.

Remarks.—This small species appears to be allied to or perhaps a variety of the Wenlock species *O. Bouchardi*, Dav.,[2] but the ribs in the latter are fewer and the imbrications coarser.

Strophomena (?) mediocostalis, sp. nov. (Pl. XXIII, Figs. 10, 10*a*, 11.)

Description.—Shell transversely semi-elliptical, about $1\frac{1}{2}$ times to twice as wide as long; cardinal angles acute, more or less alate; hinge-line straight, at greatest width of shell; lateral and anterior margins rounded; concavo-convex, more or less flattened; valves close together. Pedicle valve gently convex, slightly bent down near anterior and lateral margins, flattened towards hinge-line; beak small, acute, not prominent nor rising above hinge-line; hinge-area narrow, triangular, steeply inclined. Brachial valve flattened or slightly concave; beak small, not prominent; hinge-area very narrow.

Interior of pedicle valve with pair of small, divergent, triangular diductor impressions extending about one-fourth the length of the

[1] Davidson: op. cit., p. 250, pl. xxxi, figs. 12–20; pl. xlvi, fig. 4.
[2] Davidson: op. cit., vol. iii, p. 209, pl. xxvi, figs. 16–23.

valve; teeth small, slender, divergent. Brachial valve with small bifid cardinal process, each arm transversely grooved; dental sockets narrow, diverging at more than right angles; low, short, rounded ridge between faint adductor scars.

Surface of valves ornamented with one conspicuous, single, strong but slender median rib, with 16–20 fine, straight, primary, radiating, raised, thread-like lines on each side, and between each pair 3–5 finer striæ or lines. A few concentric wrinklings occasionally present near cardinal angles. Shell strongly punctate.

Dimensions.

	I.	II.	III.	IV.
Length ...	10·0	10·5	8·0	14·0 mm.
Width ...	19·5	15·0	12·0	16·5 mm.

Locality.—Quarry at Upper Slade.

Horizon.—Slade Beds.

Remarks.—The presence of the median rib and character of the surface-ornamentation distinguish this form from *S. compressa*, Sow., from the Llandovery Beds, to which in general shape, contour, and internal features it is closely allied. The variety of *S. compressa* termed *llandeiloensis* by Davidson,[1] from the Llandeilo Flags, has the same points of difference, and in addition possesses larger diductor scars in the pedicle valve. The Llandovery shell appears to belong to the genus *Stropheodonta*, according to Hall & Clarke, judging from the hinge, but the transverse crenulations are not clearly visible in our Slade shell. One of our specimens, probably a young individual, as it is of small size, has much produced lateral wings, but in the majority of examples the cardinal angles are only slightly produced, though always acutely pointed.

Strophomena antiquata, Sow., var. (Pl. XXIII, Fig. 12.)

The peculiar lobed variety of *S. antiquata*, figured by Davidson[2] from the Wenlock of Dudley, occurs in the Redhill Beds of Prendergast Place, Haverfordwest. In this form the pedicle valve has a broad, deep, rounded sinus down the middle, with an elevated rounded lobe on each side passing gradually into the somewhat flattened ears. The shell is markedly transverse, being nearly twice as wide as long; the hinge-line is at the greatest width of the shell, and the cardinal angles are almost rectangular, or form an angle of about 75°. The diductor muscles in the pedicle valve form a subquadrate or subpentagonal impression about one-third the length of the valve. The Redhill specimens, being in the condition of internal casts, do not show the ornamentation of the surface, but a few concentric wrinkles are traceable in one specimen near the lateral angles. It seems to me a matter of doubt whether this form is not specifically separable from *S. antiquata*, var. *scabrosa*, which also occurs in the Ordovician of the Haverfordwest district. The shape of the shell is utterly different, and the ornamentation as seen in the typical Wenlock examples is completely distinct.

[1] Davidson: Mon. Silur. Foss. Brach., vol. iii, p. 316, pl. xlvi, figs. 11–14.
[2] Davidson: op. cit., p. 299, pl. xliv, fig. 3.

The dimensions of two Redhill specimens are the following:—

	I.	II.
Length	7·0 ...	8·5 mm.
Width	13·0 ...	16·0 mm.

PLECTAMBONITES PAPILLOSA, sp. nov. (Pl. XXIII, Figs. 13, 13*a*, 14, 15.)

DESCRIPTION.—Shell small, transverse, broadly semicircular, twice as wide as long; widest at hinge-line; concavo-convex to plano-convex; cardinal angles sharp and angular, but not produced. Pedicle valve weakly convex, flattened laterally; hinge-line straight; beak small, inconspicuous, not rising above hinge-line; hinge-area narrow, inclined, with triangular delthyrium below beak. Brachial valve slightly concave or nearly flat, flattened laterally; beak very small; hinge-area very narrow, linear. Interior of pedicle valve with small, short, divergent, divaricator scars, extending about one-fourth or one-fifth the length of the shell; teeth short, small, diverging, supported by short dental plates. Brachial valve with short crural plates and cardinal process (characters obscure). Interior of both valves very coarsely papillose, the papillæ large, more or less elongated, and radially but irregularly arranged. Surface of valves ornamented with regular, straight, fine radii of equal size, increasing in number by intercalation of secondary rather finer ribs, about two-thirds to three-fourths the length of the primary, to about 60–80 ribs round the margin.

DIMENSIONS (average).

Length	3·0 mm.
Width	6·0 mm.

LOCALITY.—Quarry at Upper Slade.

HORIZON.—Slade Beds.

REMARKS.—This pretty little species occurs in fair abundance at Upper Slade. It is certainly distinct from *P. sericea*, as its internal characters prove. *P. tenuissime-striata* (McCoy) has much finer and less conspicuous striæ on the surface, and the coarse papillæ on the interior seem to be absent. The undetermined species figured by Davidson[1] from Llandeilo appears to bear a considerable resemblance. '*Leptæna*' *Grayæ*, Dav.,[2] and '*Lept.*' *llandeiloensis*, Dav.,[3] have somewhat similar ornamentation, but ours has not a lobed shell like the former, and the interior of the latter is quite distinct. The two valves are frequently attached and open, as is often the case with *P. plicatella*, Ulrich,[4] an allied form from the Utica group of America. There is no trace of cardinal spines in any of our specimens, but the general characters of the shell recall *Chonetes*.

ATRYPA IMBRICATA, Sow. (Pl. XXIII, Fig. 16.)

This species is stated by Davidson[5] to range up from the Bala to

[1] Davidson: op. cit., vol. iii, p. 330, pl. xlix, fig. 22.
[2] Id., Suppl., vol. v, p. 171, pl. xii, figs. 23–25.
[3] Ibid., p. 171, pl. xii, figs. 26–29.
[4] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 1, 1892, pl. xv A, figs. 34, 35.
[5] Op. cit., vol. iii, p. 135, pl. xv, figs. 3–8.

the Wenlock Limestone; and our specimens, which come from the Slade Beds near St. Martin's Cemetery, Haverfordwest, show the typical characters. It has been found in the Chair of Kildare Limestone, but apparently has not previously been recorded from the Bala of South Wales. It seems to be in both cases a rare species.

ZYGOSPIRA HICKSI, sp. nov. (Pl. XXIII, Figs. 17–19.)

DESCRIPTION.—Shell subcircular or ovoid, subglobose, biconvex. Pedicle valve larger than brachial, strongly convex, occasionally with faint traces of median fold; beak incurved. Brachial valve less convex; beak small, overlapped by that of pedicle valve; weak median depression sometimes present on surface of valve. Interior of pedicle valve with stout, short teeth widely separated; small transverse ridge from tooth to tooth; elongated, subparallel, muscular impressions extending nearly half the length of valve and broadening slightly anteriorly, with low ridge between them; no dental lamellæ. Interior of brachial valve with hinge-plate, broad, stout, and cleft in middle into two triangular portions; low median rounded ridge dividing paired impressions of adductors. Surface of valves ornamented with 25–30 simple, straight, rounded, radiating ribs of equal size, without bifurcation or intercalation of shorter ribs; regular, fine, concentric striæ present.

DIMENSIONS.

Length	10 mm.
Width	9·75–10 mm.

LOCALITIES.—Cuckoo Grove Lane, Haverfordwest; Upper Slade.

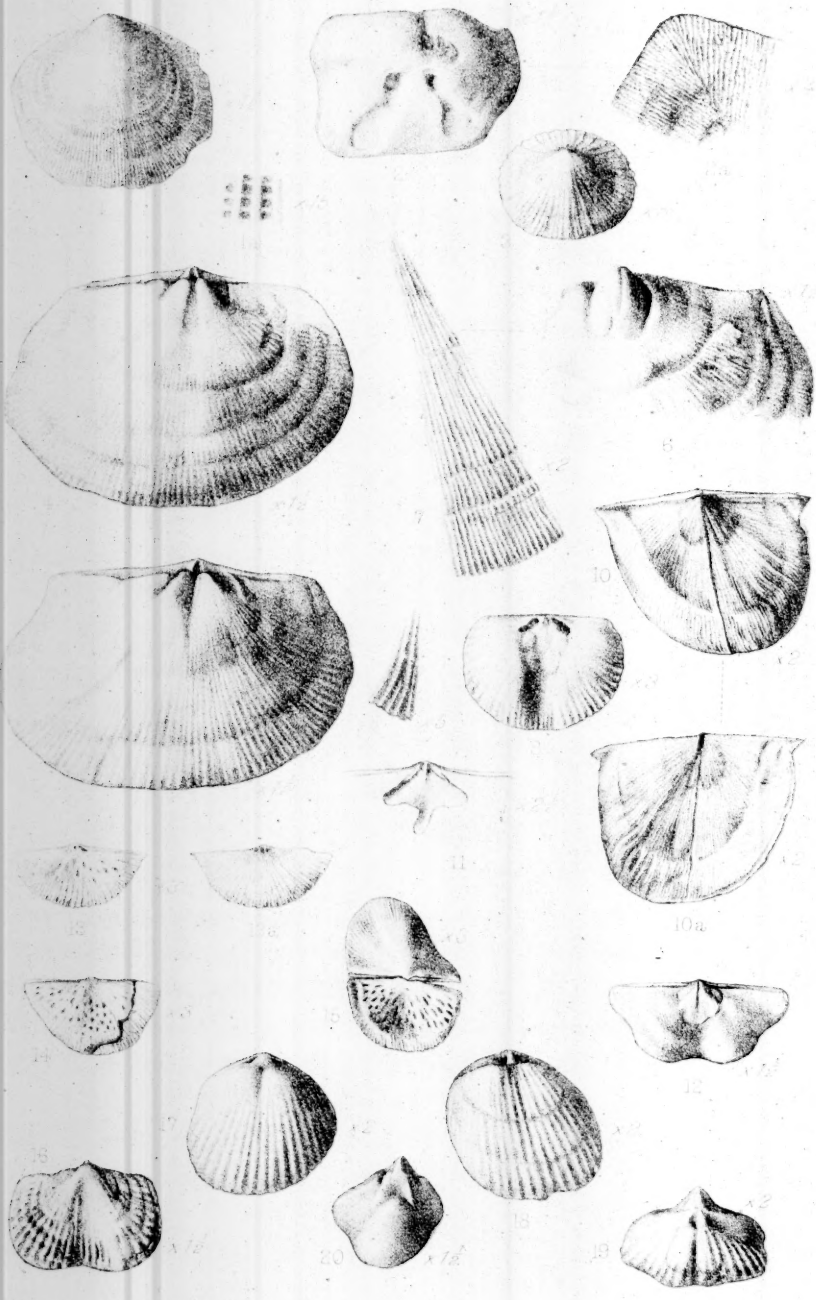
HORIZON.—Slade Beds.

REMARKS.—This interesting shell appears to belong to the genus *Zygospira* (or perhaps its subgenus *Catazyga*), for though we are ignorant of much of its internal structure, and have not seen its brachial spires, yet in its shape, ornamentation, and internal characters, so far as they are known to us, it closely resembles members of this genus. *Zygospira* is known in the British Lower Palæozoic by the form referred by Davidson to *Atrypa* (?) *Headi*, var. *anglica*.[1] There does not seem to be any very marked line of separation between *Zygospira* and *Catazyga*, which Schuchert employs as a generic name; Hall,[2] for instance, considers *Z. anticostiensis* to be intermediate between them. The smaller specimens of this Slade shell in our collection are of a more elongated and ovoid shape, but otherwise appear to be identical with the larger subcircular form. *Z. Headi*, var. *anglica*, differs from our species in having more numerous (forty or more) ribs which are also finer, and in having the muscle-scars in the pedicle valve slightly different; and on the whole it seems to belong to another species.

HYATTELLA PENTAGONALIS, Reed (?). (Plate XXIII, Fig. 20.)

The muscular impressions of *H. pentagonalis*[3] are unknown, but

[1] Davidson: op. cit., vol. iii, pl. xxii, figs. 1–8; suppl., vol. v, p. 127.
[2] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 2, pp. 154–159.
[3] Reed: Quart. Journ. Geol. Soc., vol. liii (1897), pp. 75–77.



H. M. Woodward del. et lith.

West, Newman imp.

Ordovician Brachiopoda, from Haverfordwest.

there is an internal cast of the pedicle valve of a shell which in shape and other characters resembles this species, and possesses muscular characters like those of the genus, especially like those of the type-species *H. congesta*, Conr.[1] The pedicle cavity, the subparallel, short dental lamellæ, and a subrhomboidal sharply bounded muscular scar, angularly notched behind, and comprising the two diductors enclosing the narrow contiguous adductors, are clearly seen. The specimen is imperfect, but must have measured about 12 mm. long by 10 mm. wide.

Locality.—Bank Saeson, Whitland.

Horizon.—Slade Beds.

Meristella cf. crassa, Sow.

Several imperfect internal casts and external impressions of a species of *Meristella* occur in the Slade Beds near St. Martin's Cemetery, Haverfordwest. In external form and internal features they agree closely with *M. crassa* (Sow.)[2]; in the pedicle valve we find the dental lamellæ pursuing the same course, and the muscular area and diverging lateral vascular impressions are precisely similar; in the brachial valve the cleft hinge-plate and median longitudinal septum are developed in the same manner. The external shape of the shell and smooth character also agree. *M. crassa* occurs in the Lower Llandovery, and this Slade form may prove to be a separate species or a variety.

EXPLANATION OF PLATE XXIII.

Fig. 1.—*Trematis multistriata*, sp. nov. Brachial valve. Lower Llandeilo Limestone: Lampeter Velfrey. × 1½.

,, 1*a*.—Ditto. Portion of surface of same specimen. × 15.

,, 2.—*Crania Turnbulli*, sp. nov. Cast of interior of upper valve. Sholeshook Limestone: Sholeshook railway cutting. × 1½.

,, 2*a*.—Ditto. Impression of part of surface of shell of same specimen, showing ornamentation. × 4.

,, 3.—*Crania Grayi*, Dav., var. Slade Beds: near St. Martin's Cemetery, Haverfordwest.

,, 4.—*Orthis* (*Plesiomys*) *porcata*, McCoy, var. nov. *sladensis*. Cast of interior of brachial valve. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 1½.

,, 5.—Ditto. Ditto. Same horizon and locality. × 1½.

,, 6.—Ditto. Cast of portion of interior of pedicle valve. Same horizon and locality. × 1½.

,, 7.—Ditto. Impression of part of surface of shell, showing ribbing. Same horizon and locality. × 2.

,, 8.—*Orthis* aff. *Bouchardi*, Dav. Cast of interior of brachial valve. Redhill Beds: Prendergast Place. × 3.

,, 9.—Ditto. Impression of part of surface, showing ribs. Redhill Beds: roadside near St. Martin's Cemetery. × 5.

,, 10.—*Strophomena* (?) *mediocostalis*, sp. nov. Cast of interior of pedicle valve. Slade Beds: Upper Slade. × 2.

,, 10*a*.—Ditto. Impression of exterior of same valve and specimen. × 2.

,, 11.—Ditto. Cast of interior of anterior part of brachial valve. Same horizon and locality. × 2½.

,, 12.—*Strophomena antiquata*, Sow., var. Cast of interior of pedicle valve. Redhill Beds: Prendergast Place. × 1½.

[1] Hall & Clarke: Palæont. New York, vol. viii, Brach., pt. 2, 1894, p. 61, pl. xl, figs. 23–28.

[2] Davidson: op. cit., vol. iii, p. 117, pl. xiii, figs. 1–3.

Fig. 13.—*Plectambonites papillosa*, sp. nov. Exterior of pedicle valve. Slade Beds: Upper Slade. × 3.
,, 13*a*.—Ditto. Cast of interior of same valve and specimen. × 3.
,, 14.—Ditto. Pedicle valve, showing portion as cast. Same horizon and locality. × 3.
,, 15.—Ditto. The two valves in natural juxtaposition. Same horizon and locality. × 3.
,, 16.—*Atrypa imbricata*, Sow. Pedicle valve. Slade Beds: Cuckoo Grove Lane, Haverfordwest. × 1½.
,, 17.—*Zygospira Hicksi*, sp. nov. Cast of interior of brachial valve. Slade Beds: Cuckoo Grove Lane, Haverfordwest. × 2.
,, 18.—Ditto. Cast of interior of brachial valve, showing hinge, etc. Same horizon and locality. × 2.
,, 19.—Ditto. Cast of interior of umbonal portion of pedicle valve, showing teeth, etc. Same horizon and locality. × 2.
,, 20.—*Hyattella pentagonalis*, Reed (?). Cast of interior of pedicle valve. Slade Beds: Bank Saeson, Whitland. × 1½.

IV.—The Recent Geological History of the Baltic. Part III: The Western Part of the Sea, the Sound, and the Belts.

By Sir H. H. Howorth, F.R.S., F.G.S.

(*Concluded from the September Number, p.* 413.)

PROCEEDING westward, the fauna again increases in richness. The molluscan fauna of the Gulf of Kiel has been elaborately described by Meyer and Möbius in their well-known work entitled "Fauna der Kieler Bucht." They thus enumerate the shells found there:—

Opisthobranchia.

Pontolimax capitatus.
Elysia viridis.
Embletonia Mariæ.
E. pallida.
Æolis alba.
Æ. Drummondii.
Æ. papillosa.
Æ. exigua.
Æ. rufobranchialis.
Dendronotus arborescens.
Polycera ocellata.
P. quadrilineata.
Ancula cristata.
Doris pilosa.
D. proxima.
D. maricata.
Philine aperta.
Acera bullata.
Cylichna truncata.
Amphisphyra hyalina.

Prosobranchia.

Chiton marginatus.
Tectura testudinalis.
**Litorina litorea.*
L. obtusata.
**L. rudis.*
Lacuna divaricata.
L. pallidula.
**Rissoa inconspicua.*
**R. octona.*
R. striata.
**Hydrobia ulvæ.*
†*Velutina haliotoidea.*
**Cerithium reticulatum.*
†*Triforis perversa.*
Buccinum undatum.
**Nassa reticulata.*
Fusus antiquus.
†*Pleurotoma turricula.*
Odostomia rissoides.

Lamellibranchia.

**Mytilus edulis.*
Modiolarca discors.[1]
M. nigra.
M. marmorata.
**Montacuta bidentata.*
**Cardium edule.*
**C. fasciatum.*
Cyprina islandica.
**Astarte borealis.*
†*A. sulcata.*
A. compressa.
**Tellina balthica.*
†*Tellina tenuis.*
**Scrobicularia piperata.*

[1] In the previous part of this paper, at p. 412, lines 3 and 23 from top, for *Modiolaria* read *Modiolarca*.—H. H. H.

Scrobicularia alba.
Solen pellucida.
**Corbula gibba.*
**Mya arenaria.*
†*M. truncata.*
†*Saxicava rugosa.*
†*Pholas crispata.*
†*P. candida.*
Teredo navalis.

Among these molluscs those marked with an asterisk are common and found in large numbers, while those marked with a dagger are scarce. The remaining species occur sometimes commonly, and are sometimes scarce. Thus say our authors: "When we began our work *Teredo navalis* was common. It then seems to have become extinct, and afterwards began to occur again. *Solen pellucida* became similarly uncommon after being frequently found." They attribute the scarce forms to vagabonds which have made their way from the Cattegat into the Bay of Kiel, especially in the embryo stage, and they mention in addition to such casual visitors among the molluscs certain other vagabond marine animals as taken in August and September, 1861, the Cœlenterates *Bolina alata, Melicertum georgicum, Steenstrupia rubra,* and a species of *Bourgainvillia,* while in 1869 a species of *Rhizostoma Cuvieri* found its way there (id., xxiii).

Petersen, in addition to the molluscs mentioned by Meyer & Möbius from Kiel harbour, also names *Cardium exiguum*, var. He substitutes *Astarte Wallhami* for *Astarte sulcata* as given by M. & M., *Abra alba* for *Scrobicularia alba* of the same writers, and also adds *Scrobicularia plana*, a form unknown to Jeffreys, but as he does not quote *piperata* he possibly treats this as a synonym. Nor does he mention *Tellina tenuis* and *Teredo norvegica.*

In regard to the Gasteropods from Kiel, he substitutes the generic name *Acmæa* for *Tectura*, in which he seems to be wrong (see Jeffreys, iii, 246). He names *Velutina lævigata* and *V. haliotoidea,* both of which are treated as synonyms (ibid., iv, 242), and neither name occurs in the list of M. & M. He apparently substitutes *Bela utricula* for the *Pleurotoma turricula* of M. & M. He properly substitutes the generic name *Utriculus* for those of *Cylichna* and *Amphisphyra* of M. & M., and gives the species *obtusus* while omitting that of *hyalinus*, M. & M., from Kiel, and he adds to the *Rissoas* of M. & M. from the same place the species *membranacea, octona,* and *inconspicua.*

Meyer says that his information went to show that virtually the same marine fauna which he described from Kiel also occurs in the harbour of Flensborg, and he only names one additional mollusc thence.

This completes our survey of the Mollusca in the Southern and Western Baltic, and it will be seen how rapidly it becomes richer as we get nearer to the sources of ocean water in the west.

The gradual change in the size of the molluscs which I noticed in the Eastern Baltic as we proceed eastwards is also paralleled in the Western Baltic. Thus *Litorina litorea,* which in the North Sea has a normal length of 32 mm., in the Kiel Gulf only reaches 27 mm., while *Buccinum undatum,* which is normally 120 mm. long in the North Sea, is only 58 mm. at Kiel and 55 mm. at Travemünde. Möbius and Heincke have remarked the same

fact in regard to the size of the fish of the Western Baltic compared with those of the North Sea, while their bodies are distorted and the armature of their skins with spines and similar excrescences is more marked. It has also been noticed that the sexual maturity of the animals in these brackish waters arrives earlier than in salt. The stunting of the forms is also true of the worms and Crustaceans, and Braun tells us that the *Aurelia*, the only worm which reaches the Bothnian Gulf, is only 6 mm. in length there. Norquist has noticed that among the Copepods the same stunting takes place, that it is most marked in the females, and that in the matter of the size of the antennæ and furca there is a great variety between the individuals of the same species in the Baltic and the North Sea. Brandt expresses himself most emphatically that this stunting and change, which are thus so general, are due to the gradual sweetening of the water as we advance further from the sea.

Having examined the distribution and characteristics of the living fauna of the Western Baltic let us proceed a step further. The Cattegat communicates with the Baltic by three passages, the Sound and the two Belts, and in all three there is a marked enrichment of the molluscan fauna as compared with Kiel. This is largely due, no doubt, to the fact that the narrowness of their channels and the speed of their currents cause the indraft of salt water from the North Sea to be less mixed with the fresh-water outward current than it is in the districts further to the south and east, i.e. in the true Baltic.

The Sound—'Oresund,' as it is known to the Danes—is much the most important of these water conduits, and the only one of whose zoological features, so far as I know, we have a detailed description. This is contained in the monograph by Örsted entitled "De regionibus Marinis," etc., published at Copenhagen in 1845. He describes it as lying between 55° 20′ and 56° 18′ N. lat., and as bounded on the north by a line joining Gilleleje and Kullen, while its southern limit is a similar line joining Stevns and Falsterbo. Its length is 13 miles. Its greatest width, from Copenhagen to Malmö, is four miles, while at its narrowest, between Kronborg and Helsingborg, it is 6,340 cubits ('cubitorum' is the word used). Örsted divides it into three sections. The most northern, extending as far as Helsingor and Helsingborg respectively, is a mere prolongation of the Cattegat. The middle portion extends as far as Copenhagen and Barseback; and the southern one, which is a mere prolongation of the Baltic, extends to the southern limit already named. The middle portion is alone properly called the Sound.

According to Örsted there have been found 427 forms of animals, exclusive of infusoria, in the Sound. These are thus classed :—

Fishes	90	Vermes	110
Crustacea	77	Radiata	58
Arachnida	3	Mollusca	89

Thus, in the class of Mollusca alone the number of species is considerably greater than that of the Baltic, as measured by the havens of Kiel and Flensborg.

The shells found in the Sound, according to Örsted, are:—

Limnæa balthica.
Paludinella ulvæ.
P. baltica.
P. vulgaris.
Neritina balthica (a var. of *fluviatilis*).
Trochus cinerarius.
Nucula, n.sp.
N. margaritacea.
Leda rostrata.
L. intermedia.
Modiola vulgaris.
M. discrepans.
Litorina litorea.
L. petræa.
L. rudis.
L. retusa.
L. fatalis.
Lacuna quadrifasciata.
L. canalis.
L. pallidula.
Nassa reticulata.
Purpura lapillus.
Cerithium danicum.
Acera bullata.
Bullæa aperta.
Tergipes lacinulatus.
Limapontia nigra.
Velutina capuloides.
Buccinum undatum.
Fusus antiquus.
Fusus sp.
Trophon clathratum.
Cardium echinatum.
Abra tenuis.
A. nitida.
Psammobia faroensis.
Cryptodon flexuosum.
Tellina depressa.
T. tenuis.
T. balthica.
Astarte dammoniensis.
A. striata.
Lucina radula.
Cyprina islandica.
Venus gallina.
Solen pellucidus.
Hiatella arctica.
Mya truncata.
M. arenaria.
Thalassia intestinalis.
P. tubifera.
Doris tuberculata.
Doris, n.sp. (like *verrucosa*).
D. obvelata.
Polycera quadrilineata.
Defrancia sp.
Rostellaria pespelicani.
Dentalium entale.
Mytilus edulis.
Cardium edule.
Corbula nucleus.
Mactra solida.
Mactra, n.sp.
Pecten opercularis.
P. striatus.
P. septemradiatus.
Anomia squamula.
A. undulata.
A. aculeata.
Anomia, n.sp.
Idalia caudata.
Tritonia velata.
Eolidia papillosa.
Actæon minutum.
Patella pellucida.
P. virginea.
P. tesselata.
Chiton cinereus.
C. ruber.
Ascidia rustica.
Paludinella sp.
,, ,,
,, ,,
,, ,,

Örsted does not give names to these four species, as he had not seen the animal, but only dead shells (id., p. 70). He also refers to three new species of *Ascidia* to which he does not give names (id., p. 74).

The living fauna of the two Belts is not so well known as that of the Sound, but it apparently has the same lesson for us.

Meyer tells us he found in the Little Belt, between the islands of Fänö and Fünen, in half a day's dredging, several species, such as *Doto coronata*, *Saxicava rugosa*, *Flustra foliacea*, and *Solaster papporus*, which do not occur in the Baltic, while in a few hours' fishing in the Great Belt he added the following species of marine animals to those occurring in the true Baltic (Meyer & Möbius, i, xix):—

Trochus cinerarius.
Aporrhais pespelicani.
Scalaria communis.
Eulima distorta.
Trophon clathratus.
Leda caudata.
Saxicava rugosa.
Balanus porcatus.
Pomatoceros triqueter.
Psolus phantopus.

Echinus drobachiensis.	*Ophiura texturata.*
Echinocyamus angulosus.	*Nonionina crassula.*
Amphidetus cordatus.	*Bulimina scabra.*
Ophiopholis aculeata.	*Miliolina seminulum.*

In addition to the eloquent testimony of these lists it should be remembered that in the Sound certainly, and probably in the Belts, the number of species is larger in their northern than their southern parts. The evidence is, in fact, complete and conclusive that these three conduits are mere outlets of the Cattegat, and their contents, like the contents of marine origin in the Baltic, are colonists from that wide arm of the sea, which migrated at the time of the shattering of the ancient land-bridge, and thus became highways by which the salt water of the Cattegat and a portion of its living contents found their way into the Baltic.

We cannot any longer doubt that the whole of the marine fauna and flora of the Sound, the Belts, and the Baltic are comparatively quite recent immigrants, and that before the breakdown in the bridge just referred to there were none of them to be found south of the northern entrances of the three waterways in question. A parallel case to this breakdown and its consequences is quoted by Reclus, who says :—

"The litoral 'cordon' which bounds the Limfiord on the west has been broken down several times by tempests, notably in 1624, 1720, 1760, and on Nov. 28th, 1825, when terrible inundations overwhelmed the low districts of the North Sea. . . . . The outer beach of the Limfiord, known as the Harboore Tange, was broken down, and the waters of the lake were once more united to the sea by one of the numerous Nymunde (new mouths).

"Before the opening of the breach at Agger all the western part of the Limfiord formed a fresh-water lake, but the intrusion of the sea water and the recommencement of a marine current caused great changes. Multitudes of fish entered it, while the proportion of salinity rose to 18 per thousand, and oyster beds were formed here and there. This new entrance was not used for navigation till 1854, and it was subject to great oscillation, at one time not having more than 1½ metres on the bar and sometimes 3 metres. In 1863 a new mouth was opened at Ron. In 1875 that at Agger was again closed by the sea." ("Nouvelle Géographie," v, 10.)

What it is a little startling to find, however, is that not only have all the marine forms of life in the Baltic and its three inlets migrated thither recently, but actually in the human period and during the so-called Neolithic or second Stone age; and that all the variations, distortions, and stunting of various forms of marine life in the Baltic which differentiate them from the similar forms in the open sea, and which, in this view, become more than ever important and deserving of study, have arisen since man occupied the country.

It seems to me that this fact makes it very important that all the forms of life in the Baltic should be subjected to a newer and closer analysis than they have yet received, with the object of ascertaining how far and in what way the marine fauna of the North Sea has

been sophisticated in various ways, quite lately, in order to adapt it to the conditions of brackish water in the Baltic.

Let us now take another step. It will be quite obvious to everybody that when the breakdown in the land-bridge so frequently referred to in these papers took place it was not only the Baltic and its fauna which was certain to be affected, but the Cattegat; only that in the latter case the effect would be the opposite of what it was in the former. The breakdown in question no doubt opened a gate for a great inflow of salt water from the Cattegat, but the same operation opened a corresponding gate by which the fresh waters of the vast *Ancylus* sea flowed into the Cattegat, and in this way reduced their salinity very materially.

Of this we have some very interesting and curious evidence in the extinction of certain molluscs in the southern part of the Cattegat which once lived and thrived there, as we know from the shell mounds and raised beaches and kitchen middens of the northern shores of the Danish islands and the southern shores of the Cattegat itself.

This important induction was first made in 1888 by the Danish conchologist C. G. J. Petersen. He thus compares the fossil and the living shells he had found in the Odense fiord in the island of Fuen ("Om de Skalbærende Mollusken udbredningsforhold i de Danske haven, etc.," p. 50):—

Fossil Shells.	Living Shells.
Odostomia sp.	*Utriculus obtusus.*
,, ,,	*Acera bullata.*
Utriculus truncatulus.	*Hydrobia ulvæ.*
Hydrobia ulvæ.	*Rissoa membranacea.*
Rissoa membranacea.	*R. striata.*
R. striata, var.	*Lacuna divaricata.*
R. inconspicua.	*Litorina litorea.*
Litorina litorea.	*L. obtusata.*
L. rudis.	*L. rudis.*
L. obtusata.	*Cerithium reticulatum.*
Cerithium reticulatum.	*Nassa reticulata.*
Triforis perversa.	*Buccinum undatum.*
Nassa reticulata.	*Tectura testudinalis.*
Anomia squamula.	*Modiolarca discors.*
Ostrea edulis.	*Cardium edule.*
Mytilus edulis.	*C. exiguum*, var.
Cardium exiguum (typical).	*Mytilus edulis.*
C. edule.	*Macoma (Tellina) balthica.*
Macoma (Tellina) balthica.	*Abra alba.*
Scrobicularia plana.	*A. nitida.*
Venus (Tapes) pullastra.	*Solen pellucidus.*
V. (T.) aureus.	*Mactra subtruncata.*
Montacuta bidentata.	*Thracia papyracea.*
Mya arenaria.	*Corbula gibba.*
And in a neighbouring place a valve of *Tapes decussatus.*	*Saxicava rugosa.*
	Mya truncata.
	M. arenaria.

Petersen was the first to see and to emphasize the importance of these lists, especially when compared with other evidence to be presently referred to. He pointed out that among the molluscs

which once evidently flourished in the Odense fiord are some which can no longer live in the southern part of the Cattegat. Among these he specially mentions *Ostrea edulis*, *Cardium exiguum* (the typical form), *Tapes decussatus*, *T. pullastra*, and *T. aureus*.

The oyster, which once apparently lived as far south as the Ekernfiord, no longer lives south of a line from Anholt to the Horsens fiord. On the Swedish coast it does not occur living south of Marstrand. On the Jutland side, while it occurs, but not abundantly, at Skagen, it flourishes in the western part of the Limfiord.

The former occurrence of the oyster in great banks where it must have greatly thrived, where it will no longer live, was further confirmed by the examination of the so-called kitchen middens, which contain an abundance of oysters and whose distribution is very interesting. They are not found in the interior fiords and channels and the belts between the islands, but are almost entirely limited to the shores of the Cattegat and the Limfiord. Thus, writing in 1867, Valdemar Schmidt says that more than a hundred kitchen middens were then known, nearly all of them on the shores of the Cattegat and the Limfiord. The west coast of Jutland and Schleswig have none of these deposits, showing how they have been worn away by the sea. The greater part of those occurring in Zealand are found on the borders of the Roeskilde fiord and the other branches of the Ise Fiord, thus at Kattingevek, at Bregnebierg, at Herlevspynt, at Bilidt, at Gjevningepynt, at Gierdrup, at Soelayer, at Havelse, and quite near to Roeskilde, at the bottom of the fiord at Bierget, at Haraldsborg, at Bogenas, and at Askhoved.

On the Limfiord there is one near the town of Aalborg, on the Signalbakke, which rises 60 metres above the sea-level, others at the Oesterbakker (oyster hills), at Roerdal, Restrup, and Gudumlund.

Further towards the south there is one on the north shore of the Mariagerfiord, another at Visborg, 500 metres long, others at Subaken, Hadsund, Repshaek, etc.; while the south shore of the fiord presents others over an extent of 10 kilometres. We then come to the deposits at Meilgard, at Kolindsund, now a lake, but once an arm of the sea, Kaloe, etc., etc. In the Horsens fiord we meet with a mass of oysters at the bottom of the bay called Norrestrand; at Boller we find remains of mussels and cockles. The Veile fiord presents several deposits, such as that at Bredhalla. The northern coast of Fuen also has its kitchen middens. Schmidt says that sometimes, as at Gudumlund, which is 10 kilometres from the sea, we find such a kitchen midden, but he says in such cases they were planted on an arm of the sea which has been lost by elevation. He says further that in Central and South Denmark kitchen middens were partially inundated by the sea, e.g. one used to exist at Viele.

The presence of the oyster here of full size was long ago commented upon. Thus Lyell says: "*Ostræa edulis* cannot live at present in the brackish waters of the Baltic [he ought to have said the Southern Cattegat] except near its entrance, where,

whenever a north-west gale prevails, a current setting in from the ocean pours in a great body of salt water. Yet it seems that during the whole time of the accumulation of 'the shell mounds' the oyster flourished in places from which it is now excluded. In like manner the cockle, mussel, and periwinkle, which are met with in great numbers in 'the refuse heaps,' are of the ordinary dimensions which they acquire in the ocean, whereas the same species now living in the adjoining parts of the Baltic only attain a third of their natural size, being stunted and dwarfed in their growth by the quantity of fresh water poured by rivers into that inland sea" ("Antiquity of Man," pp. 13 and 14).

We can hardly doubt that the extinction of the oyster in the southern waters of the Cattegat was due to the same cause which exterminated the *Litorinas*, the *Rissoas*, and the *Scrobicularia piperata* in the Eastern Baltic, which I have described at great length in an earlier paper, namely, the breakdown of the land-bridge, which affected the salinity of the water.

Baer showed that the oyster cannot live in water holding more than 37 parts in a thousand of salt or less than 16 or 17 parts; and it seems plain that when the oysters were living in the Southern Cattegat the waters of the latter, as Petersen urged, and as has been generally conceded, were both salter and warmer.

The oyster is not alone in having had to move further northward, as is attested by the shell-beds and also by the kitchen middens, which contain other edible molluscs. The typical form of *Cardium exiguum* and *Tapes pullastra*, found with the oyster in the raised beds and kitchen middens of the Southern Cattegat, have now withdrawn to the Limfiord, and chiefly to its western part, which is the most salt.

Tapes pullastra still lives on the Swedish side of the Cattegat with its relative *T. aureus*, but not further south than Bohuslan, while *T. decussatus*, the most remarkable of all, which Steenstrup found fossil at Kolindsund and in the Havelse and Mariager fiords (see "Oversigterne over Videnskahemes Selskabs Förhandlungen," p. 188), is not found living now in either of the great fiords, nor in fact south of Bergen in Norway. At Marieburg, Steenstrup also found *Pecten varius* and species of *Parthania* and *Odostomia*, now only living further north, as at Lighed and in the Limfiord.

From the prevalence of several species of *Tapes* in the beds at this horizon Petersen called them the *Tapes* beds. His view that they argued a greater former salinity in the Southern Cattegat has been generally accepted by the Scandinavian zoologists and geologists. De Geer argued that the access of more salt water in ancient times to what is forthcoming now was due to the fact of the Limfiord having been open and there having been a continuous current through it into the Baltic, but I cannot think this can ever have been the controlling cause of such an important change.

What reduces the salinity of the Southern Cattegat is the immense outpouring of brackish water from the Baltic, the result of the vast quantities of fresh-water continually pouring into it from its many

rivers, and so long as this outpouring has taken place so long must the salinity of that sea have been greatly lowered. I have no doubt that the migration of the *Tapes* fauna northward was due to the inrush of the fresher water from the Baltic, which first poured out of it in any great quantity when the great Baltic breach occurred.

From this evidence it is plain that the Western Baltic and its three waterways furnish complete confirmation of the conclusion forced upon us by the evidence of the Eastern Baltic, namely, that the land-bridge once separating the Cattegat fiord from the great *Ancylus* sea was broken down in the human period, and, as the western evidence shows, after the period when the kitchen-middenmen lived in Denmark.

The same evidence also points to the breakdown having been rapid or sudden, for, so far as we know, there is no evidence of the gradual dwarfing and distortion of the *oysters* and the *Tapes*, but they went out of existence when in full prosperity, as if the cause of their death and extinction was a catastrophe. We can hardly resist the further conclusion that during the period when the kitchen-midden-men were laying down their refuse heaps, the Baltic was a fresh-water inland sea, and the Cattegat was much salter than now, with a salinity and a zoological and botanical facies very like those of the present Skagerack and North Sea; and that these same men could then pass to and fro over a continuous land-bridge into and from Skäne in South Sweden dryshod, and without any necessity for boats.

Errata in previous Papers.

Page 316, line 25, *for* at Rördam *read* as Rördam says.
Page 411, line 30, *for* Skalbarende *and* udbredningsfolhold *read* Skalbærende *and* udbredningsforhold.

V.—Rodents from the Pleistocene of the Western Mediterranean Region.

By Dr. C. I. Forsyth Major, F.Z.S.

I. *Geographical Distribution of Prolagus, a Tertiary type of Mouse-Hares (Ogotonidæ), during the Pleistocene.*

In a former publication[1] I have dealt with the anatomy of *Prolagus sardus* (Wagn.), from the Sardinian and Corsican Pleistocene, in comparison with that of its Tertiary relatives. The following pages deal with the geographical distribution of Pleistocene *Prolagus* and its bearing on more general questions.

When Cuvier discovered, in the ossiferous breccia of Corsica, remains of a '*Lagomys*,' which he believed to be closely related to the Siberian *Lagomys alpinus*, he also suggested other analogies between the faunas of the two regions—Siberia and Corsica (as well as Sardinia), and commented upon the supposed relationship between the insular Mouflon and the Siberian Argali.[2] Similar views were expressed by R. Wagner.[3]

[1] Forsyth Major, "On Fossil and Recent Lagomorpha": Trans. Linn. Soc. Lond. (2), vol. vii, pp. 433–520 (1899).
[2] "Ossements fossiles," vol. iv, pp. 201, 202 (1823).
[3] Denkschr. d. Münchner Akademie, vol. x, p. 783 (1832).

Pumpelly,[1] Locard,[2] and Lortet[3] sought to establish a connection between a supposed Corsican 'ice-age,' as attested by the trace of ancient glaciers, and the former existence in the island of a supposed inhabitant of cold regions, the *Lagomys corsicanus*. Hensel had, however, shown before, in 1856, that the affinities of *Lagomys sardus* from the Sardinian bone breccia are not with the recent *Lagomys* (*Ogotona*), but with a Miocene type, for which he proposed the generic name *Myolagus*[4] (antedated by *Prolagus*, Pomel). He was in consequence inclined to assume a Tertiary age for the breccias in which the *Prolagus* occurred (and, indeed, for the whole of the Mediterranean bone breccias). A similar view has again been brought forward of late years.[5]

I myself pointed out (1) that the Corsican *Lagomys* likewise belonged to the genus *Prolagus*, as indeed had already been suspected by Hensel[6] from his inspection of Cuvier's figures; (2) that the Tertiary age of the Corsican and Sardinian breccias could not be upheld, above all, because the mollusca occurring in them, as Locard had shown to be the case in the ossiferous breccia of Toga, near Bastia, are still living in the neighbourhood.[7]

Not the least interesting feature in the history of insular *Prolagus* is its contemporaneity in Corsica with Neolithic man, of whose food it formed a part.[8] The same observation has been made independently of late years by Monsieur le Capitaine Ferton, who explored some Neolithic stations in the South of Corsica.[9]

The fact that the fauna of the insular breccias proves to be totally different from the contemporary fauna of the surrounding continents[10]—and, so far as the mammalia are concerned, different also from the present fauna of these islands—was the starting-point for my subsequent work on the island life of the Western Mediterranean region.[11] To state briefly one of the principal points: I was led to consider the Sardinian and Corsican Pleistocene faunas as relics of the Tertiary period.

[1] R. Pumpelly, "Sur quelques traces de glaciers dans l'île de Corse": Bull. Soc. géol. France (2), vol. xvii, p. 81 (1860).

[2] A. Locard, "Note sur les Brèches osseuses des env. de Bastia (Corse)": Arch. Mus. Hist. Nat. Lyon, vol. i, pp. 48, 49 (1872).

[3] Lortet, "Étude sur le Lagomys corsicanus (Cuvier) de Bastia (Corse)": ibid., p. 56.

[4] Zeitschr. deutsch. geol. Ges., vol. viii, pp. 689–703 (1856).

[5] Centralbl. f. Min. Geol. und Pal. No. 18, p. 562 (1902).

[6] Op. cit., p. 696.

[7] Forsyth Major, "Breccie ossifere e stazione neolitica in Corsica": Rend. R. Ist. Lomb. Scienze e Lettere (2), vol. xiii, pp. 432–435 (1880).

[8] Forsyth Major, "Scoperte Paletnologiche in Corsica": Archivio per l'Antropologia e l'Etnologia, vol. x (1880).

[9] Ch. Ferton, "Sur l'Histoire de Bonifacio à l'époque néolithique": Actes Soc. Linn. Bordeaux, vol. liii, pp. 129–147, 347–366 (1898).

[10] Forsyth Major, in Atti Soc. Tosc. Sc. Nat.; Proc. Verb., 9th March, 1879, p. lxxii; id., in Kosmos, vol. vii, p. 6 (1883).

[11] Forsyth Major, "L'Origine della Fauna delle nostre isole": Atti Soc. Tosc. Sc. Nat.; Proc. Verb., vol. iii, pp. 36–42, 113–133, 192 (1881–83). Id., "Die Tyrrhenis. Studien über geogr. Verbreitung von Thieren und Pflanzen im westl. Mittelmeergebiet": Kosmos, vol. vii, pp. 1–17, 81–106 (1883). Id., "Ancora la Tyrrhenis": Atti Soc. Tosc. Sc. Nat.; Proc. Verb., pp. 13–21 (1883).

Professor C. De Stefani, after having strenuously opposed—and distorted—my views,[1] adopted my remarks as his own on the distinctness of the post-Pliocene faunas of those islands. Among his 'novel' observations on the island of Sardinia is the following:—"Le quaternaire est représenté par des grès très récents et par une infinité de brèches osseuses contenant une faune abondante et étrange, tout à fait détachée des formes continentales, de rongeurs, d'insectivores, et même de carnivores d'un type spécial."[2] Thus it has come to pass that in the last two editions of De Lapparent's Manual of Geology[3] the credit for these observations, and for the conclusions drawn from them, is given to the Italian writer, who of all men had done his utmost to discredit these observations and conclusions when they were expressed by myself.

At the time of publication of "Die Tyrrhenis," the most recent continental deposits known to contain remains of *Prolagus* were the lignites of Casino in Tuscany. I therefore looked towards that geological period for a presumed connection of Corsica with continental Europe. "On European soil the *Myolagus* (= *Prolagus*) existed last as a contemporary of the *Hipparion* (Casino); at that period, therefore, there may have still been in existence a connection between Corsica and the Italian Peninsula."[4]

Next came Depéret's discoveries, in the Middle Pliocene of Perpignan (Roussillon), of abundant remains of a *Prolagus*, which the writer considered indistinguishable from the Corsican form. This observation led to his ingenious hypothesis of an isthmus uniting the crystalline formations of Western Corsica with those of the Maures (Southern France); an isthmus which separated two regions of the Pliocene Mediterranean, distinguished from each other by a difference in their respective molluscan faunas. "C'est par cet isthme que les animaux pliocènes du continent ont pu émigrer sur la terre de Corse et s'y perpétuer plus longtemps même que sur le continent, jusque dans les temps pléistocènes. Il n'est par impossible même, étant donné la présence en Corse d'espèces actuelles de mammifères et de l'homme, que cette communication se soit maintenue jusqu'à une époque assez récente."[6]

I had myself hinted[7] at the possibility of a union in the direction advocated by Depéret; I do not see, however, that a connection with Italy in an anterior period is excluded by Depéret's arguments.[8] The Pliocene sea in the region between Corsica and Tuscany, attested *inter alia* by the marine deposits of the island Pianosa, was posterior to the Casino horizon, which coincided with,

[1] Bull. Soc. Malacol. Ital., vol. ix, pp. 224–230 (1883).
[2] C. De Stefani, "Nouvelles Observations géol. sur l'île de Sardaigne": C. R. Paris, vol. cxiii, p. 607 (1891).
[3] A. de Lapparent, "Traité de Géologie," 3me ed., p. 1540 (1893); 4me ed., pp. 1804, 1805 (1900).
[4] "Die Tyrrhenis . . . . .": Kosmos, vol. vii, p. 106 (1883).
[5] Ch. Depéret, "Les Animaux Pliocènes du Roussillon": Mém. Soc. géol. France; Paléontologie, Mém. No. 3, pp. 56, 122 (1890).
[6] Ch. Depéret, "Etude de quelques gisements nouveaux de Vertébrés Pléistocènes de l'île de Corse": Ann. Soc. Linn. Lyon, vol. xliv, pp. 125, 126 (1897).
[7] Kosmos, vol. vii, p. 105.
[8] Op. cit., pp. 125, 128.

or followed immediately upon, the period of the maximum of regression of the Mediterranean, a period the marine equivalents of which are not yet known.

As to the supposed presence in the Corsican Pleistocene fauna of recent mammalian species, I know none, with the exception of the *Cervus corsicanus* and *Ovis musimon*, which last certainly during the Pleistocene was already an inhabitant of Sardinia, and most probably also of Corsica. Depéret gives a list of the species recognised by Cuvier, Lortet, and himself in the "poches à Lagomys" of Corsica[1]; I myself had also given a list from my own collections.[2] Depéret's list includes the following recent species of mammals: *Myoxus glis*, *Mus sylvaticus*, "*Arvicola* groupe d'*amphibius*," *Canis vulpes*, *Ovis musimon*.

The *Ovis musimon* of Lortet's list,[3] "Mouflon, ou probablement une autre espèce semblable," rests on a rib! In Sardinian deposits I found some teeth and an incomplete skull, which I found to agree with *O. musimon*. The *Canis vulpes*, given with doubt in Lortet's list, again rests on 'ribs.'

The vole collected by myself in the Toga breccia, near Bastia, is not an *Arvicola* of the *amphibius* group, but an extinct form, *Arvicola Henseli*, Maj., which frequently occurs in the Sardinian Pleistocene, and of which more will be said hereafter.

The *Mus* found by myself at Toga is not *Mus sylvaticus*, but the extinct '*Mus*' *orthodon*, Hens. My description of this species[4] is partly based on specimens from the Corsican locality, partly on Sardinian specimens (breccia of Bonaria, near Cagliari).

Monsieur Claude Gaillard has most kindly forwarded to me the remains of a *Glis* from Toga, preserved in the Lyons Natural History Museum; they are two left mandibular rami and several bones of the skeleton. There is no doubt that it is the recent species *Glis glis* (= *Myoxus glis*), but it is quite as certain also that these remains have a fresher appearance than those of the *Prolagus*. The difficulty is that, so far as I know, *Glis* has not been mentioned as a member of the recent Corsican fauna; that does not, however, imply that it may not exist in the island.

The fauna of the Corsican breccias, in my opinion, lends support to the hypothesis that the isthmus spoken of may still have subsisted in older Pleistocene times, but certainly not later.

A new aspect of the geographical distribution of *Prolagus* is afforded by the occurrence of this rodent in Pleistocene *continental* deposits. In a recent notice Depéret reports on the discovery, in a cave at Gracia, close to Barcelona, of a Lower Pleistocene fauna, including *Rhinoceros Mercki*, a small form of *Cervus elaphus*, and numerous remains of *Prolagus corsicanus*.[5]

[1] Op. cit., p. 122.
[2] Kosmos, vol. vii, p. 6 (1883).
[3] Arch. Mus. Hist. Lyon, vol. i, p. 43 (1872).
[4] Atti Soc. Tosc. Sc. Nat.; Proc. Verb., vol. iv, pp. 139–145 (1884).
[5] Ch. Depéret, "Sur l'origine et la dispersion géographique du *Lagomys corsicanus*": C. R. Paris, vol. cxxxv, pp. 884–886 (1902). See also Almera & Bofill y Poch, "Consideraciones sobre los Restos fosiles cuaternarios de la Caverna de Gracia (Barcelona)": Mem. R. Acad. Ciencias y Artes de Barcelona, vol. iv (3), No. 33, pp. 7, 8 (1903).

Gibraltar.—In the "Ossements fossiles" Cuvier reproduces a drawing by Adrian Camper of a specimen from the Gibraltar bone breccia in Camper's collection; the specimen exhibits two mandibular rami of a rodent which Cuvier determined with some doubt as belonging to '*Lagomys*.'[1] Rud. Wagner,[2] as well as Hensel,[3] were even more positive than Cuvier in excluding the genus *Lepus* in favour of *Lagomys*. For myself, I have never doubted that the two rami belong to a species of *Prolagus*, but have refrained from mentioning it, being influenced by the following statement made by George Busk: "We may . . . . in the absence of further information, perhaps be allowed to doubt whether the specimens in question really came from Gibraltar, where certainly in the enormous mass of bones and breccia examined by Dr. Falconer and myself nothing of the kind has turned up."[4] Unfortunately very little has been preserved of the "enormous mass of bones and breccia" brought together chiefly by Captain Brome's exertions and forwarded to the Royal College of Surgeons.[5]

On examining, several years ago, some scanty fragments of bone breccia from the fissure at Rosia Bay, Gibraltar,[6] in the collection of the Geological Society of London, and presented by Mr. James Smith, of Jordan Hill, I discovered in one of them (No. 6) the horizontal section of a molar tooth, exhibiting the characteristic pattern of the anterior lower premolar of *Prolagus*. There is, therefore, no more reason now to doubt of the provenance of Camper's specimens. The dimensions of the tooth—greatest longitudinal diameter = 2·4 mm.; greatest transverse diameter (behind) = 2·3 mm.—agree well with the rather large dimensions of the mandibles figured by Cuvier after A. Camper's drawing.

In the British Museum (Geological Department) is preserved a small bit of stalagmitic breccia, from Gibraltar, according to the information received (the specimen was purchased from a dealer), which contains *inter alia* a right mandibular ramus of a smaller species of *Prolagus*; this I have named (*Prolagus calpensis*, sp.n.),

[1] Oss. foss., vol. iv, p. 174, pl. xiii, fig. 4 (1823).

[2] Op. cit., p. 763.

[3] Op. cit., p. 695.

[4] G. Busk, "On the Ancient or Quaternary Fauna of Gibraltar": Trans. Zool. Soc. Lond., vol. x, p. 58 (1876).

[5] "Some of the brightest records of the military glory and prowess of our country are indissolubly connected with Gibraltar. A great nation like England cannot afford to neglect, or disregard without reproach, whatever bears on the natural history or archæology of so renowned a possession" (Busk & Falconer, in Quart. Journ. Geol. Soc. London, vol. xxi, p. 368, 1865). Meanwhile, we leave it to French geologists to set us right on the geological age of the 'rock' (see Suess, "La Face de la Terre," vol. i, p. 229, footnote 4, 1897; and Lapparent, "Traité de Géologie," 4th ed., p. 1098, 1900), and to a German malacologist to enlighten us on the recent malacological fauna of Gibraltar (see Kobelt, "Studien zur Zoogeographie," vol. ii, pp. 225, 243, 1898). And last, not least, we *throw away* (undeveloped) palæontological collections brought together under exceptionally favourable circumstances by an enthusiastic collector.

[6] "From this fissure ton-loads of mammalian remains were obtained during the scarping of the cliffs, but unfortunately these have long been dispersed" (Ramsay & J. Geikie, in "Geology of Gibraltar," Quart. Journ. Geol. Soc. London, vol. xxxiv, p. 521, 1878).

and it is described, and figured in the Catalogue of Fossil Rodentia actually in print.

Cette.—From the ossiferous breccia of Cette (Hérault) Cuvier mentions some scapulæ—one of which is figured—of a small rabbit ('lapin'), of which it is stated, however, that it could scarcely have attained the dimensions of a guinea-pig. Cuvier remarks that very possibly these scapulæ may belong to the same species as the mandibular rami of Gibraltar.[1] This is my opinion also, and I would add besides that two incomplete metatarsal bones from the same breccia, mentioned and figured in the "Ossements fossiles,"[2] likewise belong to *Prolagus*.

Ratonneau.—Continuing our journey eastwards, we next arrive at the ossiferous breccia of the islet Ratonneau, opposite Marseilles, from whence P. Gervais obtained three molars and a lower incisor of a '*Lagomys*.'[3] Considering that in the same breccia was found a species of *Hystrix*, *H. major*, whose affinities are with Tertiary porcupines,[4] we may fairly assume that the *Lagomys* teeth also belong to the older type of the family, viz. *Prolagus*, rather than to a member of the recent genus.

(According to a statement in Almera & Bofill y Poch's paper, above quoted,[5] Messrs. Depéret & Deydier have found the *Prolagus corsicanus* in a cave of the valley of the river Durance (Vaucluse). Monsieur Marc Deydier, of Cucuron, however, kindly informs me that this statement rests on a misunderstanding.)

(*To be concluded in our next number.*)

REVIEWS.

I.—Memoirs of the Geological Survey of Great Britain and Ireland.

WE regret to find that we are rather behindhand in bringing to the notice of our readers some of the memoirs issued by the Geological Survey; but we can plead, with every hope of pardon, that the publication of our General Index has not unprofitably (so far as our contributors are concerned) occupied our time. Memoirs dealing with parts of England, Wales, Scotland, and Ireland have reached us.

I. England.—The Water Supply of Lincolnshire from Underground Sources: with Records of Sinkings and Borings. Edited by Horace B. Woodward, F.R.S., with contributions by William Whitaker, F.R.S., H. Franklin Parsons, M.D., and Henry Preston, F.G.S. pp. 229. (1904. Price 4*s.* 6*d.*)

[1] Oss. foss., vol. iv, p. 178, pl. xiv, fig. 26 (1823).
[2] Op. cit., vol. iv, p. 178, pl. xiv, fig. 27.
[3] P. Gervais, in C. R. Paris, vol. xlix, p. 511 (1859). Id., Zool. Pal. Gén., vol. i, p. 76 (1867–69).
[4] P. Gervais, opp. citt. Ch. Depéret, "Les Animaux Pliocènes du Roussillon": loc. cit., pp. 43–47 (1890). Id., in Ann. Soc. Linn. Lyon, vol. xliv, p. 125, footnote 2.
[5] Op. cit., p. 7.

This is a continuation of the series of county memoirs on water supply, of which those relating to Sussex and Berkshire have been published.

Records of all known borings and sinkings in Lincolnshire are given, together with numerous analyses of water. In the introduction there is a general account of the geological formations, especially in reference to the water-bearing strata, and a separate article on rainfall, accompanied by a map by Dr. H. R. Mill.

II. Wales.—The Geology of the South Wales Coalfield. Part VI: The Country around Bridgend. By Aubrey Strahan, F.R.S., and T. C. Cantrill, F.G.S., with parts by H. B. Woodward, F.R.S., and R. H. Tiddeman, M.A. pp. 120. (1904. Price 1*s.* 6*d.*)

This is an explanation of Sheets 261 and 262 of the Geological Survey Map (colour-printed), and deals with a bordering portion of the main coalfield of South Wales. The area is largely occupied by the Lower Lias, the Rhætic beds, and the Keuper Marls and Conglomerate—the last-named familiarly known as the Dolomitic Conglomerate. It includes the interesting tracts of littoral Lias at Sutton and Southerndown; also Aberthaw, famed for its lime and cement. A small area of Coal-measures and Millstone Grit and larger areas of Carboniferous Limestone and Old Red Sandstone are described. The hæmatite of Llanharry and the Glacial and post-Glacial deposits are duly noticed.

III. Scotland.—The Geology of West Central Skye, with Soay. By C. T. Clough, M.A., and Alfred Harker, F.R.S. pp. 59. (1904. Price 1*s.*)

This Memoir, descriptive of Sheet 70 of the Geological Map of Scotland, gives a brief account of the Tertiary igneous rocks of the Cuillins, and of the basalt plateaux lying to the north and west of that mountain group. The Torridonian rocks and the Tertiary intrusions occurring in the island of Soay are described. The patches of Triassic, Jurassic, and Cretaceous rocks found on the cliffs on the north side of the Sound of Soay are referred to. Special chapters are devoted to the Glacial and post-Glacial accumulations and to the physical features and scenery.

The Geology of the Country around Blair Atholl, Pitlochry, and Aberfeldy. By G. Barrow, F.G.S., J. S. Grant Wilson, and E. H. Cunningham Craig, B.A., with petrological notes by J. S. Flett, D.Sc. pp. 161. (1905. Price 3*s.*)

This is an explanation of Sheet 55 of the Geological Map of Scotland, the area being entirely within the Highland district of Perthshire. It is one of the most picturesque of the mountain regions, made up mainly of various schists, with the limestones of Loch Tay and Blair Atholl, some grits and quartzites, and the so-called 'Green Beds,' a term not very happily applied to "a series of sedimentary schists, sometimes pebbly, and usually containing

a considerable amount of hornblende, chlorite, or epidote." Epidiorite, hornblende schist, and gneiss, and less altered igneous rocks of many kinds, together with sundry glacial drifts, alluvial deposits and peat, make up the table of formations. The memoir is well illustrated by effective pictorial views, but it is stiff reading for the pedestrian, who, rambling along the Pass of Killiecrankie, over the heights of Ben Vrackie, on the shores of Loch Rannoch, or over Carn Mairg, wishes to gather a general notion of what geology teaches.

IV. Ireland.—The Geology of the Country around Belfast. By G. W. Lamplugh, F.G.S., J. R. Kilroe, A. McHenry, M.R.I.A., H. J. Seymour, B.A., W. B. Wright, B.A., and H. B. Muff, B.A. pp. 166. (1904. Price 3*s.*)

This is an explanation of the special one inch map of Belfast, colour-printed, with Drifts, and it is accompanied by some interesting pictorial views of the Cave Hill quarries (Chalk overlain by basaltic lavas), of the Ordovician rocks on the coast at Carnalea, and other geological features. The account of the Palæozoic and Mesozoic rocks and of the Tertiary volcanic rocks is mainly compiled from previous Survey memoirs and the published works of later observers. The chief work of the Survey was in the detailed mapping of the Drifts, and a very excellent description of these superficial deposits has been drawn up by Mr. Lamplugh and his colleagues. They point out that the chief features are pre-Glacial; the later modifications being mainly due to the partial infilling of some depressions and the carving out of narrow gorges by post-Glacial drainage. During the Glacial episode the whole area was buried under an ice-sheet, and therefore protected from direct subaerial erosion, undergoing only the more partial and probably much less rapid waste from the passage of the slowly moving mass. Water supply, agricultural geology, and other economic matters are dealt with in this Memoir.

II.—British Museum (Natural History). Guide to an Exhibition of Old Natural History Books, illustrating the Origin and Progress of the Study of Natural History up to the time of Linnæus. Compiled chiefly by B. B. Woodward, F.L.S., F.G.S., in charge of the General Library, assisted by the officers of the several departments, etc. (London, 1905: printed by order of the Trustees. Price 3*d.*)

LONG before the discovery of any records of man inscribed or carved on bones, or painted on the walls of caves and rocks, on temples, tombs, or papyri, we may feel quite certain that the earliest representatives of our race had been directed to the open book of Nature, and that plants and animals were the first object-lessons which they studied. Adam, indeed, is credited by his historian with the authorship of the earliest "Index Animalium," but no copy survives. Solomon at a later date is recorded to have been a botanist of wide knowledge, but his learning was oral and traditional and is lost to us.

Both plants and animals appear on Egyptian and Assyrian monuments, and the love of the Egyptians for animals of all sorts, especially for those held sacred to special deities, is well known.

"The ancient Egyptians, however, made no systematic study of Natural History, nor did the early Greek philosophers. Some scattered observations are met with among the writings of the latter, while to PYTHAGORAS [B.C. 569–470] have been attributed ideas concerning the changes in relative level between sea and land that may not improbably be those of later observers. HERODOTUS [B.C. 484–406] certainly mentions the occurrence of shells, presumably marine, on the hills of the Nile valley, and deduces from that and other facts the former extension of the sea over the area.[1]

"HIPPOCRATES [B.C. 460–361], the priest-physician and 'Father of Medicine,' mentions the uses of some 240 plants.

"The first person, however, to whom belongs the credit of instituting a genuine study of Natural History was ARISTOTLE [B.C. 384–322], and he has, therefore, been justly called the 'Father of Natural History.'

"His writings on Animals, of which he appears to have known some 500 species, would seem to contain a certain admixture of astronomical symbolism;[2] or else portions belonging to his astronomical writings were by an error of his first transcribers incorporated with those on animals, and this, considering the conditions under which his MSS. had been preserved, would not be remarkable. . . . . He divided animals into *Enæma*, or those having (red) blood, and *Anæma*, or those without, and subdivided the former, or VERTEBRATA, into: Vivipara, Birds, the other Ovipara and Fish; while the latter, or INVERTEBRATA, were subdivided into: Malakia, Malakostraca, Entoma, and Ostrakoderma. The insects (Entoma) he yet further subdivided, and three of his groups, Coleoptera, Psychæ [= Lepidoptera], and Diptera, hold good at the present day! . . . .

"In botany and mineralogy little was done by Aristotle and nothing in geology as now understood, although it is interesting to note in passing that he maintained the earth to be a spherical body, while he was acquainted with the occurrence of fossils in the rocks, and discussed the changes on the earth's surface necessary to account for them.

"It was Aristotle's favourite pupil THEOPHRASTUS [B.C. 371–286], to whom he bequeathed his MSS., who took up the subjects of botany and mineralogy. Minerals were at that time classified into 'metals' and 'stones,' and only his treatise on stones has survived; it is chiefly interesting as showing what characters were made use of at that time for the discrimination of minerals and the description of the species, as well as a record of the places of their occurrence.

[1] Lyell in his "Principles" does not seem to have read Herodotus' statement quite correctly.

[2] See paper by D'Arcy Thompson, "On Bird and Beast in Ancient Symbolism"; Trans. Roy. Soc. Edinburgh, vol. xxxviii, p. 179.

"After many vicissitudes, which included burial in a catacomb, the remains of the combined MSS. of Aristotle and Theophrastus passed into the hands of Apellicon of Teos [–B.C. 85], who attempted their restoration and had them copied. The transcripts were afterwards seized by Sylla and conveyed to Rome, where they were subsequently edited and given to the world by Andronicus of Rhodes; but their real publication dates from 1495, when they were first printed in the original Greek by the celebrated Venetian printer Aldus Manutius. A Latin translation by T. Gaza of Theophrastus' *De historia et causis Plantarum* had, however, been printed at Treviso in 1483.

"Geology, or more strictly speaking, physical geography, first received serious attention at the hands of STRABO [B.C. 63?–A.D. 24], who originated the theory of the alterations of the level of the land in relation to the sea, in contradistinction to the former belief in the changes of the sea-level.[1] His *Geographicon*, which was written in the early years of the Christian Era, was printed, from the Latin translation, at Venice in 1472 by Vindelinus de Spira, and appeared in the original Greek in 1516 from the press of Aldus Manutius.

"The oldest popular natural history book, and almost encyclopædia, was the *Historia Naturalis*, also termed the *Historia Mundi*, of PLINY THE ELDER [A.D. 23–79]. This voluminous treatise in thirty-seven books has been preserved, and presents an epitome of the state of Roman knowledge on the subject. The number of known plants had by this time increased to about one thousand, and the belief in the existence of sexes in plants had become established; while in the minerals the 'earths' had been made into a class apart from 'metals' and 'stones.' It was probably the earliest work on natural history to be printed, the editio princeps emanating from J. de Spira's press at Venice in 1469.

"The next most important work was the celebrated *Materia Medica* of DIOSCORIDES [A.D. 40?–]. This was a standard book for over a century, and was the basis for most of the early herbals.

"It was first printed at Medemblik, Holland, in 1478, from a Latin translation, made by Hermolaus Barbarus. The Greek editio princeps, from the press of Aldus Manutius, at Venice, appeared in 1499. The work became the subject of much discussion, and of many Commentaries by early botanists of the Renaissance, especially P. A. MATTIOLI [1500–1577] and his contemporaries, who, ignorant of the differences between the floras of East and West Europe, were led into endless difficulties in their attempts to identify their plants from the imperfect definitions of Dioscorides.

"The three Greek writers, Hippocrates, Theophrastus, and Dioscorides, are the authorities for all the Greek names of plants up to the Christian era.

"With the epoch of Pliny and Dioscorides the classical period of natural history may be said to have been brought to a close: the works of the older writers became less studied in Europe, and

[1] It is most probable that Ovid derived orally from Strabo the ideas which he attributes to Pythagoras in the oft-quoted passages from his "Metamorphoses."

commonplace books like those of Ælian of Praeneste, a compiler who lived in the third century, were much used. In these, scraps of folklore, travellers' tales and fragments of misapprehended science were set forth in the elegant style then affected. An edition of Ælian's collected works was issued by Gesner in 1556, and a good edition of his *De Natura Animalium* was brought out in 1774 under the editorship of Abraham Gronovius.

"The early Christian writers, none too conversant with natural history, utilized these works, without question as to their reliability, in their allegorical interpretations of Biblical texts. Hence arose a series of collections, in many languages, of some fifty Christian allegories, much read and quoted in the Middle Ages, known by the common title of the *Physiologus*, or, since most of its imagery was borrowed from the animal world, the *Bestiary*.

"On such productions as these were based the natural history writings of the Middle Ages — 'dark' indeed as regards progress in scientific learning.

"Among mediæval European writers the following deserve notice: — Albertus (Albert von Bollstädt), called Albertus Magnus [1193–1280], a Dominican, and sometime Bishop of Ratisbon, who, among his numerous writings, included commentaries on Aristotle and treatises:—*De Animalibus*, first printed in 1479, *De Mineralibus*, printed 1495, and *Tabula tractatuum parvorum naturalium* (in which were comprised his *De Vegetabilibus et Plantis*), printed in 1517.

"Vincentius Belovacensis, or Vincent of Beauvais [*c.* 1190–*c.* 1264], another learned Dominican, who resided at the court of Louis IX of France, compiled at the instance of that king a *Bibliotheca Mundi*, which is not only one of the earliest of encyclopædias, but the greatest of the Middle Ages. The first part, entitled *Speculum Naturale*, written about 1250, contains thirty-three books. It was first printed at Strasburg about 1473.

"Bartholomæus (Bartholomew de Glanville), called Bartholomæus Anglicus [fl. 1230–1250], a Minorite Friar, compiled an encyclopædia entitled: *De Proprietatibus Rerum*, which as a manuscript was known in Italy in 1283 and in England in 1296. It was first printed at Basle about 1470, and was the source of common information on natural history during the Middle Ages.

"These authors were followed after a long interval by:—

"Leonardo da Vinci [1452–1519], who was not only a great painter, but had also vast knowledge, among other subjects, of anatomy, botany, and geology. He vigorously maintained that the contents of the rocks were real shells, and supported the belief in the changes of sea and land which this view implied. His writings on these subjects were not printed from the original manuscripts till 1881 and 1883.

"Girolamo Fracastoro [1483–1553] declared his opinion that fossil shells had all belonged to animals which had lived and multiplied in the places where their exuviæ are now found, but he was not listened to."

Did space admit we might pursue the description of this interesting exhibition of "Old Masters," but anyone for a modest threepence may acquire a very carefully prepared introduction to a most remarkable series of works by early authors, some of whose writings and accompanying illustrations will well repay a visit to that most attractive Natural History Museum in Cromwell Road, which has now become one of the most valuable teaching-centres in London, and whose library is also one of the best extant, a result largely due to the energy and ability of its Librarian, Mr. B. B. Woodward, to whom we are also indebted for the present exhibition of old Natural History books and for one of the best Library Catalogues (still in progress) which has ever been printed of works bearing on Natural History.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science. Cape Town, South Africa, August 16th, 1905.

Address to the Geological Section (C) by Professor H. A. Miers, M.A., D.Sc., F.R.S., President of the Section.

(*Continued from the September Number, p.* 429.)

Doelter's Work on Melting-Points and Solubilities.

THE labours of Doelter and his pupils have been largely devoted to the melting-points of the rock-forming minerals and their solubility in silicate magmas. From experiments upon these minerals and their mixtures they have come to the conclusion that in many cases the melting-point of the mixture is about the mean of the melting-points of the constituents, and that in such cases, therefore, there is no evidence that the freezing-point is lowered, or that an eutectic mixture is formed; so that it is not safe to apply the theory of cyro-hydrates to fused mixtures of silicates.

Doelter is therefore led to regard the silicate magmas rather as mixtures of various constituents which may be dissolved in each other, but which are not by any means necessarily identical with the minerals which separate on cooling. The whole process seems to him to be far too complicated to be explained by any such simple principle as the mere relative proportions of the various constituents to each other and to their eutectic mixture; the order of crystallisation must be determined by a number of factors, such as temperature, velocity of crystallisation, the interval between the softening and fusing of each mineral (which he finds to be considerable), viscosity, capillarity, the presence of water and mineralising agents, and the absorption of adjacent rocks.

To choose a simple example: minerals such as zircon, corundum, and titanite separate for the most part early, because they are less soluble. On the other hand, magnetite is one of the more soluble minerals, and yet it is one of the first to separate; the same is to a certain extent true of augite, but not always. It is possible that

in a magma which still contains the iron of the magnetite in solution plagioclase and augite may be comparatively soluble and magnetite comparatively insoluble, but that when magnetite has already crystallised out from the magma the plagioclase and augite may be comparatively insoluble; the experiments which are wanted are experiments upon the solubility of certain minerals in magmas of known composition under known conditions; in these and similar instances the order of separation is that of the solubility, but such physical factors as the velocity of crystallisation (which varies very considerably with the temperature), and the viscosity, may completely invert the order.

Direct experiments made by Barus and Iddings upon the electric conductivity of silicate magmas afford evidence that such magmas contain dissociated as well as undissociated molecules, so that they cannot be regarded as merely fused mixtures of certain minerals. If two or more rock-forming minerals be fused together it may happen that they form new compounds and crystallise out as different minerals, or if one or the other remains unchanged it may crystallise out in a different proportion. All this shows that double decomposition goes on in the liquid. We cannot therefore expect, without knowing the degree of dissociation, to make such use of the lowering of the freezing-point in order to calculate the other factors in the process of rock-formation.

Doelter concludes that upon the whole the normal order of crystallisation in rocks is in the main that laid down by Rosenbusch long ago, namely, an order of increasing acidity, but that it is determined by the mutual affinities of the molecules in the magma, and by the relative power of crystallisation of the components into which they unite themselves, and that the physical factors which I have already enumerated play a very important part in the process. No one has endeavoured more systematically than Doelter to determine for the rock-forming minerals the melting-points and the solubilities, without which it is impossible to make much progress in our reconstruction of the history of rocks. He has recently shown us how the microscope may be used in the study of fused silicates at high temperatures, and has so opened up a new field of research.

Vogt's Applications of the Laws of Solutions.

The work of Vogt has extended over many years, and is now summarised in two remarkable memoirs recently published by him, in which are expressed his mature opinions upon silicate magmas: the reasoning is based upon his own experiments, upon those of Doelter, and upon the classic researches of Ebelmen. It is now generally conceded that the particular minerals produced in a silicate magma depend much more upon the chemical composition of the magma than upon temperature and pressure; Lagorio and Morozewicz were led to this conclusion by their own experiments upon fused silicates. Experiments upon slags at ordinary temperatures and pressures may, therefore, be invoked to elucidate the formation of rocks.

In 1902 Vogt stated his conviction that the laws of solutions may be applied to igneous rocks, and his two recent memoirs are, in fact, an attempt to explain the experiments upon slags and fused silicates as examples of the operation of these laws.

All-important, according to him, is the composition of the eutectic mixture; he finds that if the analyses of silicate magmas be arranged according to their oxygen ratio or acidity, the various minerals of which they consist make their appearance within fairly well-defined limits. For example, in the case of the Ca Mg Fe Mn slags, which contain little alumina, olivine and the melilite minerals only make their appearance in the more basic slags, and the metasilicates in the more acid, the limit between the two corresponding to an acidity of about 1·6.

The limit of individualisation between the various minerals is supposed to correspond to their eutectic mixture. Such slags may, therefore, be regarded as a mutual solution of two or more of the minerals olivine, enstatite, hypersthene, augite, the gehlenite-melilite group, akermanite, wollastonite, and the hexagonal metasilicate, which is so characteristic of the more acid slags. The particular minerals which make their appearance are practically determined by the acidity of the magma and by the relative proportion of the bases present, particularly by the ratio of the calcium to the magnesium-iron-manganese group; in other words, Vogt asserts that a silicate magma is a mutual solution of the various crystalline compounds that actually make their appearance as it solidifies, and that the order of crystallisation depends upon their proportion in the magma as compared with their proportion in the eutectic. The old conception of a solvent and a solute ceases to have much meaning; the matter which is of supreme importance is the nature of the eutectic mixture when the constituents are given; thus micropegmatite and microfelsite represent the eutectic of felspar and quartz, and correspond to a mixture of about 74 parts of felspar to 26 of quartz, as indeed has been stated by Teall.

Now, if we are justified in regarding rock-magmas and fused silicates as mutual solutions of certain definite compounds, and if these compounds are actual minerals or other silicates which crystallise out of the magma when it cools, we are also justified in making use of the properties of these minerals when we apply to the magma the known physico-chemical laws which govern solutions.

The number and nature of the minerals which can be in equilibrium with each other and the solution are to be determined by experiments upon their solubility interpreted by the phase-rule of Willard Gibbs, and especially by the laws which Roozeboom and other physical chemists have deduced for components which form double salts or isomorphous mixtures. Knowing the components, we ought, therefore, to be able to determine their latent heat of fusion, their specific heat, the lowering of the freezing-point of their mixtures, and from these data to calculate the true formulæ of the rock-forming minerals. It will readily be understood that in a mixture of quartz and orthoclase, the lowering of the freezing-point below that of either of

the constituents, as calculated by Van 't Hoff's formula, from their melting-points, latent heats, and molecular weights, will be very different according as the formula of quartz is taken to be SiO_2 or Si_3O_6.

Vogt boldly attacks the whole problem as one that can be solved on these lines: we have good reason to believe that the slags and rock-magmas are solutions; we know their constituents; we can therefore proceed to experiment with these constituents and to predict the behaviour of their mixture according to the principles of physical chemistry. The order of crystallisation is mainly determined by the relative composition of the magma and the eutectic, and the composition of the eutectic may be calculated from the intersection of the freezing-curves.

One interesting result is the conclusion that in the silicate magmas which have been the subject of experiment the minerals produced are all of very simple constitution; that, for example, olivine, diopside, akermanite, melilite, and anorthite have the simplest possible formulæ corresponding to their analyses, and are not polymerised. Mineralogists will welcome this conclusion if it be true, for it has occasionally been the fashion on theoretical grounds to attribute a high degree of polymerisation to many minerals, and nothing is easier than to account for many difficulties if one may multiply the formula of a mineral by any number that is required. It should be added, however, that Doelter, calculating from his own experiments, is led to think that some of the minerals must have formulæ which are multiples of their empirical formulæ.

Vogt even goes a step further in his application of the principles of modern chemistry. The order of crystallisation appears to be by no means always that of the solubility, but indicates that a mineral is sometimes not so soluble as might be supposed. Now another principle in the modern physics of solutions is that by adding to a solution of one substance a new electrolyte containing an ion common to both the solubility of the first is diminished, and Vogt does not hesitate to apply this principle.

Thus spinel and felspar in mutual solution, when felspar is in large excess, should on cooling yield felspar first. But in many basic rocks spinel is the first to crystallise; this is, according to Vogt, due to the presence of ferro-magnesian silicates containing the Mg ion which is also present in spinel; if these be partially dissociated the solubility of the aluminate will be lowered.

An obvious criticism on this argument is that if the dissociation is so slight that it may be ignored for one purpose, it is hardly fair to invoke its powerful action for another, and it is possible that Vogt in his enthusiasm for a theory attempts to explain too much by its aid.

It is clear, however, that the labours of Vogt have been precisely in the direction indicated by Teall in the words that I have quoted, "experiment controlled by the modern theory of solution"; and if his opponents are tempted to think that he may have carried the principle too far with insufficient data, they cannot but admire the brilliancy, the persistency, and the ingenuity with which he has applied the newer theories of solution at every turn.

Heycock and Neville's Work on Alloys.

I must next refer briefly to another remarkable series of researches which have recently been published.

The laws which govern the solutions of metals in metals, that is to say alloys, appear to be the same as those which prevail in the case of other solutions; it is in alloys that the nature of eutectic mixtures has been most fully studied; and the phase-rule and Roozeboom's deductions from it have been applied with signal success to their investigation. A new impulse has been given to the subject by the work of Heycock and Neville, which is summarised in their Bakerian lecture delivered last year upon the copper-tin series of alloys. They have studied the changes which occur during the cooling of an alloy by taking small ingots of the cooling metal and chilling them at certain temperatures; this arrests the gradual process of cooling, and causes all that is liquid at the moment of chilling to become suddenly solid; it is then possible by polishing and etching the ingot to show the solid crystals set in the congealed ground-mass and to study their nature. They have been able to interpret their results by means of Roozeboom's remarkable work on the solidification of mixed crystals published in 1899. For our present purpose it is sufficient to consider these results as applied only to alloys. If a diagram be constructed with the temperatures for ordinates and constitution for abscissæ, Roozeboom has shown that two curves may be drawn. The first is the freezing-point curve, or *liquidus*, giving the temperatures at which an alloy of any composition begins to solidify: this is a broken curve, and each section of it represents the temperature of equilibrium between the liquid and a different solid alloy; the breaks represent the temperatures and constitution of the liquid at which one solid ceases to be produced and another begins. The curve is, of course, far more complicated than the simple V of Meyerhoffer, since that represents the cooling of a mixture whose constituents do not form compounds or isomorphous mixtures, whereas the alloys do both. In this respect the alloys resemble a silicate magma which is crystallising as a rock-mass; indeed, it will be remembered that Mendeléef insists upon the general similarity of silicon compounds to metallic alloys.

The second curve of Roozeboom is the melting-point curve, or *solidus*, representing the temperatures at which an alloy of given composition becomes completely solid. Points above the liquidus represent the condition of alloys which are completely liquid; points below the solidus that of alloys which are completely solid; points between the two that of cooling alloys which are only partially solid; and the curves themselves show which solid compounds can be in equilibrium with the liquid and with each other at any temperature.

The cooling-curves of Roberts-Austen and Stansfield had shown that considerable evolutions of heat may occur in cooling alloys far below the temperature of solidification, indicating that changes are going on in the solid as well as in the liquid condition. Heycock and Neville carry their investigations below the temperature of complete solidification and study these changes also.

In the case of the copper-tin series of alloys they find that, according to the temperature and constitution of the liquid, crystals belonging to no less than six different types may separate, namely:—

α, a solid solution of Cu with less than 9 per cent. of Sn.
β, a solid solution of Cu with less than 27 per cent. of Sn.
γ, of which the constitution is not known.
ϵ, which probably has the composition Cu_4Sn.
η, which probably has the composition Cu_3Sn.
H, which probably has the composition Cu Sn.

Both β and γ are unstable at ordinary temperatures. The compound ϵ crystallises out of β or γ while they are already in the solid state, when the temperature falls sufficiently.

A glance through the 101 photographs of chilled and etched ingots which accompany Heycock and Neville's paper on this series of alloys shows how impossible it would be from the final composition of the solid alloy to ascertain the various stages through which it has passed during cooling; as the authors remark, it is of the nature of a palimpsest. For example, the alloy, containing 14 atoms of tin to 86 of copper, consists at 800° of α crystals in a ground-mass which probably contains β; it solidifies at about 775°; at 675° there are only β crystals; at 600° there are α and β crystals, but here α has crystallised out of β after it became solid; at 530° there is a much larger proportion of α; at 470° there are α crystals immersed in a mixture of α and ϵ into which the residual β has broken up on cooling.

If the course of events is so complex in an alloy of only two metals, how much more difficult must it be to decipher in the case of a mass of complicated silicates which are even more prone to form isomorphous mixtures, such as we have in a solid rock, not to mention the additional presence of aluminates, oxides, and sulphides. And yet geologists are accustomed to speculate freely about the crystallisation of rock constituents from the magma without taking account of anything save the final stage.

I cannot help thinking that the experimental method of Heycock and Neville will have to be applied to the study of slags and fused silicates if we are to trace successfully the evolution of rock species. The value of their work to geologists is not only that the results are skilfully interpreted by the light of modern physical chemistry, but primarily that it is experimental work upon actual crystallising materials.

(*To be concluded in our next number.*)

CORRESPONDENCE.

THE CHALK BLUFFS AT TRIMINGHAM.

Sir,—Students of East Anglian geology will read with some surprise, in the concluding paragraph of the paper by Professor Bonney and Mr. Hill on the Trimingham Chalk Bluffs, that a hypothetical interpretation of these masses was out of place in a Survey memoir. Surely in a work dealing with this district some attempt

was demanded to account for phenomena which "have for many years attracted the attention of geologists" and now, even of the above-named authors themselves, albeit if with the knowledge then (1882) available an exact explanation was not possible.

Nor can it be said that Professor Bonney and Mr. Hill by their communication have advanced matters much, for unfortunately they appear to have left out of sight two rather important items, viz., the fossil contents of the beds and the literature on the subject since 1882.

Long familiarity with rocks which can only be studied stratigraphically and by aid of the microscope and field-glass may, perhaps, have led them to overlook the palæontological aspect of the Trimingham chalk masses. Professor Bonney, it is true, noticed the conspicuous Belemnite occurring throughout, but is not aware that it is of less importance as a zonal guide than the concomitant *Ostrea*, which does not occur throughout.

To thoroughly investigate the fossil fauna of a bed in cases such as the present one is not possible, however, to the casual visitant: it can only be done with long and patient research by one on the spot.

Fortunately the Trimingham chalk masses have had their historian in Mr. R. M. Brydone, who, with a care and patience that cannot be too highly commended, made a thorough examination of them, collected and worked out their fossils, and in 1900 published a pamphlet entitled "The Stratigraphy and Fauna of the Trimingham Chalk." In this he showed that the uppermost portions of the masses are the sole remaining vestiges in England of the Maestrichtian beds of the Chalk. He further discussed Mr. Clement Reid's theory, which in the light of these later researches he showed to be untenable and suggested that these masses were really buried sea-stacks. This view is supported by the Mundesley boring. Whether these pinnacles have remained upright, or have been crushed, crumpled, and overturned, is of little moment, but it is important to note that the strata in them are of the same age as the beds capping the *mucronata* chalk, that are exposed in the beach at extreme low water.

That these masses are part and parcel of the main Chalk strata that lie at no great depth under the beach at this spot, I was enabled to see in the Autumn of 1901 after a storm that had cleared away the beach for some distance round their base. The bands of flint were distinctly traceable down into and right across the exposed surface. The sketch and notes I made at the time were passed on to Dr. Rowe and Mr. Sherborn against the time when they come to deal with the Norfolk district.

B. B. Woodward.

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[We have received several other letters on this subject, all embodying the same points of criticism.—Edit. Geol. Mag.]

THE RAISED BEACHES OF DEVONSHIRE AND OF THE SOUTH OF IRELAND.

Sir,—I much regret to find that I have both misunderstood and misinterpreted Mr. Muff's ice-scored beach-platform in the South of Ireland.

Ever since Godwin-Austen in 1851 attacked the problem of the